ARTIFICIAL ANÆSTHESIA.

A MANUAL

OF

ANÆSTHETIC AGENTS

AND THEIR

EMPLOYMENT IN THE TREATMENT OF DISEASE.

BY

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FOURTH EDITION. REVISED AND ENLARGED.

WITH ILLUSTRATIONS.

PHILADELPHIA:
P. BLAKISTON, SON & CO.,
No. 1012 WALNUT STREET.
1896.

In 1847 the late Dr. Oliver Wendell Holmes created the words artificial anæsthesia, and wrote: "Nature herself is working out the primal curse which doomed the tenderest of her creatures to the sharpest of her trials; but the fierce extremity of suffering has been steeped in the waters of forgetfulness, and the deepest furrow in the knotted brow of agony has been smoothed forever."

"If America had contributed nothing more to the stock of human happiness than anæsthetics, the world would owe her an everlasting debt of gratitude."—*The late Professor Samuel D. Gross.*

PREFACE TO THE FOURTH EDITION.

Having been informed by my publishers that it would be necessary to issue a Fourth edition of my "Manual of Anæsthetics" this year (1896), it has been my endeavor to bring the whole subject of artificial anæsthesia and anæsthetics up to the present time, being careful to obtain all the most notable discoveries of the last six years.

I have examined all the *important* works published during the interval, testing in almost every instance the new anæsthetics, or modifications of the old, on myself or my friends, also the mechanical contrivances for their administration.

In visiting Europe in 1892–3, met and acted with the Committee on Anæsthetics of the British Medical Association at the meetings at Nottingham and London—at the former presented a paper of statistics on the subject of anæsthetics. By special invitation—visited the Universities of Edinburgh and Glasgow to witness the *Scotch method* of administering chloroform, a careful and conscientious statement of which I have endeavored to give.

It is somewhat remarkable that the fourth edition of this book should be issued on the fiftieth anniversary of the discovery and introduction of ether (October 6, 1846).

It is the one systemic anæsthetic which has proved, during all these years, the most available and the most free from danger.

Numerous valuable anæsthetics have been brought to the knowledge of the profession, but all had to give place to ether. A careful study of its constituents and its mode of preparation, with a careful trial of its physiological effects, have proved its value. Above all, its use in two hospitals with which we have been connected for a long time has never resulted in a death,

either in our own practice or in those operations in which we have assisted. Careless and inconsiderate individuals now and then bring discredit upon it, but in the majority of cases they should be blamed—and not the anæsthetic. No one should be allowed to administer any anæsthetic without a certain amount of tuition, and no one should receive a diploma until he has shown a knowledge of the chemical composition, and physiological action of such anæsthetics.

Efforts have been made to bring discredit upon ether. The investigations and experiments of Drs. J. Chalmers DaCosta, H. C. Wood and Carter have endeavored to prove that ether contains dangerous elements in the changes which it undergoes in the system. Also in the secondary changes which result in its after-effects, but these experiments require confirmation before being received by the profession. The action of chloroform upon the heart, kidneys and liver, and the deleterious changes resulting from its use, have been confirmed by numerous observers and experimenters, both at home and abroad. We have given as complete as possible a series of tables of death from both ether and chloroform, obtained with much labor and trouble from all the reliable sources within reach, only regretting that they are not so perfect as could be desired.

These tables fully confirm our original views, founded upon personal observation, viz., that ether is the safest systemic anæsthetic to be employed, and they further confirm the statements published upon the subject in the first edition of this work.

I desire to acknowledge many courtesies at the hands of members of the medical, pharmaceutical, and dental professions.

255 South Seventeenth Street, Philadelphia,
October, 1896.

PREFACE TO THE THIRD EDITION.

THE Author has endeavored, in this the Third Edition of his Manual, to make a thorough revision of the whole subject of Artificial Anæsthesia. The time, he thinks, has arrived, after forty-five years' (1844–1889) trials, of these most wonderful and beneficent agents, by the medical and surgical profession, to have some definite and positive opinion, as to their relative safety in the various operations, and the risks and responsibility attending their use, in the healthy and diseased conditions of the human body.

By a careful and conscientious study of each agent, its natural and physiological characteristics, and peculiarities, each and every medical man can, and should, select the one which he knows and feels will be just suitable in the peculiar case on hand.

By the discovery of true and positive local anæsthetics, and by their careful use in all minor operations in surgery, much of the risk to life is prevented.

All hopes have passed away—for the time being at least—that any one of the systemic anæsthetics is absolutely free from risk to life, for we now know, full well, that anæsthesia carried to the effect of a profound impression on the human subject, sufficient for a capital operation, is but a step from death.

It has been proven in numerous cases that it requires but a slight excess in the quantity employed, perhaps a lack of atmospheric air, great fear or dread concerning operation or anæsthetic, the faulty or non-action of a deranged kidney or heart, perchance a careless administration, and the patient is dead. In making the additions and alterations to our Manual, necessary at the present day, many changes have led to an increase in the size of this book.

We would advise all who are obliged to use anæsthetics to memorize the prominent points, so that when a case of emer-

gency arises it will not be necessary to seek information in the book, and all necessary haste, worry and confusion would be avoided, knowing just what to do for the best interest of the suffering patient, nigh unto death.

The indiscriminate and careless administration of the most powerful anæsthetic agents is the crying evil of the present day, and we feel sure that in the near future legislative action will be taken to prevent, under heavy penalty, any one from giving an anæsthetic, unless he or she be provided with a certificate that they fully understand the chemical, physiological and medical agents they are about to employ, and have had experience in their use, under a competent surgeon, and have been subjected to a careful examination of the knowledge they have thus acquired.

Human life is too valuable to be destroyed by incompetent administrators of such beneficent yet death-giving agents.

The following is the most recent warning on this subject: "The announcement that the anæsthetist in a fatal case of chloroform narcosis, at Sydney, Australia, has been found guilty and sentenced to pay two hundred pounds damages, on the ground that the anæsthetic had been improperly administered, comes with rather a startling effect. While no conscientious man, be he lay or medical, will dispute the justice of such a verdict, when negligence is clearly proven, difficulties arise when such matters are adjudicated by a jury of persons, who, whatever their intelligence, are profoundly ignorant of what constitutes negligence in this respect.

"It would be but a step further for juries to enforce the opinion, which has been gaining ground, as to the advisability of giving chloroform at all, unless specially indicated. Still, this is a matter well within the discretion of the medical man, and it would be impolitic, as well as unjust, to fetter the exercise of that discretion by a fear of legal consequences.

"Short of negligence, amounting to a criminal act, we cannot conceive of such a verdict in this country (England), and we sincerely hope that the example will not be the means of imposing an additional horror to the life of medical men, who have enough to attend to in guarding themselves against vexa-

tious actions for having signed lunacy certificates, and in avoiding the wiles of designing women with an eye to blackmail."*

The subject of the administrations of ether per rectum still claims some interest. The author retains part of the literature on that subject, modifying and giving the most recent cases which have been reported. The application of such powerful agents by the rectum offers many objections to general use, although in some rare cases it can be resorted to with success when cocaine is neither admissible nor sufficiently powerful.

In this edition of the work the author has retained the description and illustrations of the various inhalers. Some are not recommended as highly as others, but all have certain merits and demerits; still, this department has been found of practical use in the saving of time to those who are not familiar with the various modifications made or work performed. The author desires to return thanks to Dr. Buxton for his kindness in allowing his publishers to furnish several illustrations of instruments and one of tracings, the former being in constant use and highly thought of by the physicians, surgeons and dentists of Great Britain. Here, also, he makes a general acknowledgment of having freely availed himself of Dr. Buxton's labor in original communications sent to him, knowing how much they will be appreciated by his professional brethren in this country, he "being administrator of anæsthetics in several London hospitals."

The author desires to acknowledge many courtesies at the hands of several members of the medical profession.

He is also indebted to the liberality of the S. S. White Dental Manufacturing Co., of this city, for the use of valuable cuts of instruments and apparatus. Also to Parke, Davis & Co., Detroit, Mich.

The author's sole object has been to make this work a scientific yet practical and safe guide, no labor nor expense having been spared in attempting to accomplish this object.

* Dr. E. Hart, British Medical Journal.

1502 WALNUT STREET, PHILADELPHIA,
December, 1889.

PREFACE TO THE SECOND EDITION.

THE rapid sale of a large edition of this work in the short period of one year, shows the appreciation with which it has been received by the medical and dental press and professions. Its success has induced the author to revise the subject-matter and rewrite several of the articles. To make the volume more worthy of the favor of the profession, a number of new and original experiments have been made, especially with hydrobromic ether. The boiling points and relative time of evaporation of the several agents employed in mixed anæsthetics, and the best proportion in which ether, alcohol and chloroform should be united have been determined ; also a continuation of the experiments on the action of anæsthetics on the blood; the use of the spectroscope in relation to anæsthetics, more especially nitrous oxide.

In this second edition there will be found many more practical suggestions as to the employment of anæsthetics that are safe, and the rules for their adoption or reasons for the rejection of some of them in different cases, grouped, and made convenient, so that the student can memorize them, and be fully prepared for any emergency. As has been well observed in a review of this work by the distinguished editor of the *Dental Cosmos*, "When trouble comes to a patient from any cause during the anæsthetic state, it is not a good time to hunt up information."

The new table of deaths from chloroform which has been added, and in the preparation of which much time and labor have been expended, will be found of special interest and vital importance in regard to the sex, age, character of operation, time at which the patient died, quantity of chloroform used, and form of apparatus employed, general condition of patient,

prominent symptoms of chloroform-poisoning, causes of death and post-mortem appearances. A new ether inhaler has been described and illustrated, which has been, and is now, employed in the clinical service of Jefferson College Hospital.

A bibliography published in the first edition has been omitted, but additional old or new works which were not then introduced, or cannot be found mentioned in the body of this work, have been printed for reference.

A historical sketch of the discovery of anæsthesia at the end of the previous edition has also been omitted, as more space has been devoted to the subject in our introduction, but full references to all authorities on the subject have been given.

There has been introduced a notice of the metric system in accordance with the recommendations of the "American Medical Association" at its last meeting, at Atlanta, in May, 1879; also a table of the Centigrade and Fahrenheit thermometric scales. More space has likewise been assigned to the physiological and therapeutic action of anæsthetics in disease. In most of the instances where a remedy has been recommended, the authority has been quoted, or we have tested its therapeutic value in an extensive private practice, or in the daily clinics of two large public institutions.

It was found impossible to acknowledge, in every instance, the source from which all contained facts have been obtained, but in the majority of instances we have endeavored to give credit to every original worker in the field of progress. The author desires to acknowledge many courtesies at the hands of several eminent members of the profession; but he is especially indebted to his son, Dr. Charles S. Turnbull, and others.

1502 Walnut Street, Philadelphia,
June, 1879.

PREFACE TO THE FIRST EDITION.

THIS little work was originally written by the Author as a report for a medical society, and was subsequently extended to its present form to supply a want that evidently exists at the present day, for a convenient hand-book on the administration of the various anæsthetics, that the practitioner of medicine or dentistry can consult, to enable him to decide which one he can best employ. Many valuable books have, unquestionably, been written on the subject of anæsthetics, but as far as the writer's observations extend, none of a practical character have appeared within the last few years. Much useful matter in relation to sulphuric ether, "nitrous oxide," and chloroform, employed as anæsthetics, has accumulated within this period, but this valuable information is contained in various monographs, journals, etc., where, associated with what is extraneous, it is unprofitable to the busy practitioner.

The object of this work may be stated to be:

First. To give in as concise a manner as possible a description of the most available agents that may be successfully and safely employed as anæsthetics.

Second. To present the chief chemical tests of the purity of each substance considered, with its composition, physical characters and medical properties.

Third. To exhibit the best methods of administering the various anæsthetics, to give careful directions, and to state the precautions to be taken to avoid risk to the life of the patient.

Fourth. To note the personal experience of the author, his assistants and friends, with anæsthetics and the various forms of inhalers in use, with a selection of the most approved, not withholding, however, the objections, but noting the experiments of other reliable investigators.

Fifth. To compare the relative mortality from all the anæsthetics now employed, endeavoring to assist the reader in forming a fair and candid opinion of this most important subject, which has for so long a period occupied the attention of the public as well as the medical profession.

1502 WALNUT STREET, PHILADELPHIA,
March, 1878.

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ARTIFICIAL ANÆSTHESIA.

PART FIRST.

CHAPTER I.

History of Ancient and Modern Anæsthetics.

THE ancient Greeks, it is stated, possessed a plant called mandrake, which belonged to the same family as belladonna or deadly night-shade. From the root of this plant was extracted, by means of wine, a narcotic which was employed by them as an anæsthetic. Lucius Apuleius, who lived about 160 A.D., and of whose works eleven editions were published in the fourteenth and fifteenth centuries, says, "that if a man has to have a limb mutilated, sawn or burnt, he may take half an ounce of mandragora wine, and whilst he sleeps the member may be cut off without pain or sense." To prove that this was true, Dr. B. W. Richardson, of London, after a lapse of five centuries, obtained a fine specimen of mandragora root, and, after making wine from it and testing it, found it was a narcotic having precisely the properties that were anciently ascribed to it. He discovered that in animals it would produce even the sleep of Juliet, not for thirty or forty hours, a term that must be accepted as a poetical license, but for the four hours named by Dioscorides; and that, on awakening, there was an excitement which tallied with the same phenomenon that was observed by the older physicians. Another fact was noticed by the ancients—that many volatile substances acted more promptly when inhaled than when taken into the stomach, and the first-named form of medication was employed in Greece, Rome and Arabia.

By the works published in those countries the knowledge of these facts was extended to other parts of the world. "He has eaten mandrake" was said of a very indolent and sleepy man, from the narcotic and stupefying properties of the plant, well known to the ancients.

> CLEOPATRA.—"Give me to drink mandragora
> * * * * *
> That I might sleep out this great gap of time
> My Anthony is away."
> —*Shakespeare*, "*Anthony and Cleopatra*," act i., scene 5.

In China, in ancient times, the word ma-yo meant not only Indian hemp but anæsthetic medicine; other substances besides hemp entered into the benumbing recipes, such as the datura, a solanaceous or soothing plant, probably identical with the atropia or mandragora; also aconite, hyoscyamus, etc. A wine of mandragora was used by the Romans to relieve the sufferings of the crucified, and was employed (down to the thirteenth century) as a surgical anæsthetic. Some of these drugs form constituents of the formula said to be employed by kidnappers of children and by robbers; consequently their sale or employment is, at the present, prohibited in China. Dr. Dudgeon, of Pekin, writing in 1877, gave a flat contradiction to the extravagant stories current in Europe respecting the skilful use made by the early Chinese of benumbing drugs, and probably a more exact acquaintance with the fact would show that the practice of Greece and Rome was not less elementary. Only in modern times and in the light of scientific teaching was it possible for anæsthetics to take their proper place as helpmates of the surgeon in his art and as the grand alleviators of human suffering.

Theodoric, about the year 1298, gives elaborate directions how to prepare a "spongia somnifera" by boiling it dry in numerous strong narcotics and afterwards moistening it for inhalation before operations.

Opium was also employed in later years (prior to surgical operations), and was found the best narcotic for the relief of pain and for producing insensibility, although not free from danger.

History of Modern Anæsthesia and Anæsthetics.

On September 3, 1828, M. Girardin read to the Academy of Medicine, of Paris, a letter addressed to His Majesty, Charles X., describing "surgical anæsthesia by means of inhaled gases."

A strong impulse was given to the study and application of the "different kinds of airs and gases" by the discovery of oxygen by Priestly and Scheele in the middle of the eighteenth century, and numerous experiments were made by physicians with the new gas.

Pneumatic chemistry called into existence a new branch of therapeutics—pneumatic medicine, as it is named by its founders, who hoped to cure diseases, especially pulmonary tuberculosis, by the inhalation of various gases and vapors. This has been again revived in our day. A "Medical Pneumatic Institution" was set up at Clifton, in 1798, by Dr. Beddoes, which had huge reservoirs of gases for the use of patients. The celebrated Humphrey Davy, who had then just served his apprenticeship, was appointed superintendent. Though not successful in the immediate object for which it was founded, it was so in another sense; for here Davy made his researches concerning nitrous oxide gas. In 1800 he discovered that when inhaled this gas produced a peculiar intoxicating effect, together with an irresistible propensity to muscular exertion, and often to laughter, whence its popular name of "laughing gas." He also discovered its anæsthetic properties and successfully inhaled it himself to relieve the pain of cutting a wisdom tooth. He made numerous experiments with the gas on animals. In his account of these experiments there occurs this memorable and oft-quoted sentence: "As nitrous oxide in its extensive operation appears capable of destroying physical pain, it may probably be used to advantage during surgical operations in which no great effusion of blood takes place." Those desirous of pursuing the subject further should read his work entitled, "Researches, Chemical and Philosophical, Chiefly Concerning Nitrous Oxide." Strange to relate, notwithstanding their completeness, nothing came of these remarkable observations. Their real import was not understood until nearly half a century later.

The modern practice of anæsthesia, though it may have been benefited indirectly by these experiments, was not the immediate outcome of any of them; it originated to a large extent independently. The honor of making this discovery rests chiefly with four Americans—Horace Wells, William Morton, Charles Jackson and Crawford W. Long.

One winter's night in December, 1844, a number of the inhabitants of Hartford, Connecticut, assembled to hear a lecture on nitrous oxide and other gases by Dr. Colton, a well-known popular lecturer, who tried the effect of the first-named gas on several of the audience. Among those present were Horace Wells and his friend, John M. Riggs, both dentists of that city. They noticed that a person under the influence of the gas was capable of sustaining a severe injury of his leg without apparently feeling any pain. Wells was so impressed with this fact that on the following day he had the lecturer permit him to inhale the gas, and whilst under its influence he had a molar tooth extracted without feeling the least pain. As he recovered from the effects of the gas his first words were: "A new era in tooth-pulling."

The modern practice of anæsthesia dates from this operation. Wells appears to have been unaware of Sir Humphrey Davy's experiments. He found the peculiar exhilarating effects described by Davy due to mixture of the gas with atmospheric air; for when precautions had been taken to exclude the latter only anæsthetic effects ensued from its inhalation.

Wells gave the gas to more than a dozen of his patients and with complete success. Elated with this good fortune, he quickly obtained permission to make a public trial of it at the Massachusetts General Hospital. Unfortunately, the bag was removed too soon, and in the extraction of the tooth the patient uttered a piercing cry. The sceptical audience rudely hooted and hissed, and Wells was laughed at as an ignorant pretender. Now, Wells was a modest and retiring man; he felt the insult deeply. Home he went, mortified and disgusted, yet both Wells and Riggs continued in their practice to administer the gas, but never afterwards resumed their experiments in public. After a few years Wells fell ill from vexation, and retired from his profession. Subsequently, he visited Europe as a picture

dealer, then returned to the United States, became more and more unsettled in his mind, and finally died by his own hand in January, 1848. For a long time Wells' just claims as the discoverer of modern anæsthesia were ignored; indeed, we are only now beginning to do justice to his memory. He, at least, never attempted to make a secret of his great discovery nor to use it for selfish ends. "On making the discovery," says Wells, "I was so much elated respecting it that I expended my money freely and devoted my whole time for several weeks in order to present it to those who were best qualified to investigate and decide upon its merits, not asking or expecting anything for my services. I was desirous that it should be as free as the air we breathe. Judge, therefore, of my surprise, after the lapse of many months, when I was informed that two individuals (Drs. Jackson and Morton) had claimed the discovery and made the application for a patent in their own names."

We are happy to state that a chaste and handsome monument, with a statue of Wells, has been erected at Hartford, Connecticut, with the following inscription:

"Horace Wells, who discovered Anæsthesia,
December 10th, 1844."

Much credit is due to Dr. McManus and other friends of Wells for their praiseworthy efforts in this matter.

I am glad to be able to present a likeness of Horace Wells, which, no doubt, will give pleasure to thousands who now profit by his valuable discovery.

The use of nitrous oxide as an anæsthetic, for the time being, died with Wells, and the discovery was again in danger of being lost. Dr. Colton's praiseworthy efforts to reintroduce the gas were vain until 1863, when he succeeded in inducing a few practitioners to try it. Its use spread rapidly, so that in 1867—the year of the International Exhibition in London—he was able to visit Paris with a record of 20,000 administrations without a single accident. He met with very little encouragement from the Paris faculty. However, in the spring of the following year, *his* apparatus was brought to London by Dr. Evans, the American dentist resident in Paris, who administered the gas before the

staff of the Dental Hospital, and thus introduced the practice in that country.* In the United States nitrous oxide was well received; and in 1870 Dr. Colton published in a medical journal, and afterwards in pamphlet form, the result of the physiological action of the gas in its practical application to the original discoveries of Davy, Wells and others, with a very large record of the successful extraction of teeth.

Unfortunately, owing to the comparative feebleness of action of nitrous oxide gas, and its large gaseous bulk, the anæsthesia

PLATE 1.

can only be maintained for a very limited period. Hence the employment of the gas has hitherto necessarily been restricted to short surgical operations. The late M. Paul Bert partially succeeded in overcoming this objection by giving instead of the pure gas a mixture with oxygen gas, in the proportion of 85 volumes of nitrous oxide to 15 volumes of oxygen, *under increased atmospheric pressure* in a special chamber constructed for this purpose. The necessity for the latter part of this provision arises from the fact that when the mixture of the gases

* The Journal of the British Dental Association.

is inhaled alone complete anæsthesia cannot be produced, owing to the full complement of nitrous oxide (45 volumes to 100 volumes of oxygen) not being taken into the lungs during respiration. Under the increased pressure mentioned sufficient nitrous oxide is inhaled to produce anæsthesia and sufficient oxygen to prevent the supervention of asphyxia. Thus more or less prolonged anæsthesia can be maintained. After many experiments on animals this method has been tried at the Paris Hospital by Peau and others, but with partial success. It is not known whether it is employed in this country. The requisite apparatus in its present form is too cumbrous and expensive for general use. A more compact apparatus has been invented by Dr. Hewitt, of London, and with it the nitrous oxide mixture can be kept up for some time, and thus a short operation, or the extraction of a number of teeth, etc., can be undertaken.* A full account will be given under nitrous oxide.

CHAPTER II.

The Discovery of Special Anæsthetics and the Theory of their Action —Local Anæsthesia and Anæsthetics — Chloroform—The True Value of Anæsthetics—Cocaine—Eucaine Hydrochlorate.

Ether.

"PEREIRA," in his famous work, then as now a familiar text-book,† states, "The vapor of ether is inhaled . . . . to relieve the effects caused by the accidental inhalation of chlorine gas." Again, he writes, "If the air is too strongly impregnated with ether stupefaction ensues." The crowning result, however, was obtained in 1846 by Dr. Morton in the Massachusetts General Hospital, when it was demonstrated successfully that the inhalation of ether was so capable of deadening the sensibility of

* The Journal of the British Dental Association.

† Lectures on Materia Medica and Therapeutics, vol. ii.

the nervous system that an operation, no matter how painful, could be performed without suffering to the patient. In the use of ether as an anæsthetic the first capital operation—that is, one involving one of the larger joints—was performed on October 17, 1846, by Dr. Warren, of Boston.

A handsome sum of money should have been given both Dr. Wells and Morton for their devotion to the cause of suffering humanity, and this should still be done for their families. It gives me pleasure to be able to present a correct likeness (Plate 2) of Dr. Morton, who, though he erred, should long ago have been forgiven for his devotion to the introduction of one of the most valuable anæsthetic agents given to the profession and the public.

Dr. Jackson, of Boston, claims to have suggested to Dr. Morton the use of ether as an anæsthetic in place of nitrous oxide. With regard to this, it may be stated that at a meeting of the Boston Academy of Arts and Sciences, where the matter was being discussed, the late Professor Louis Agassiz said to Dr. Jackson: "Did you make even one little experiment with ether?" and, after receiving a negative reply, added dryly: "It would have been better if you had." On another occasion Professor Agassiz said: "If Dr. Morton had killed his first patient would you (Jackson) have accepted the blame, just as now you ask for the honor?" Dr. Jackson was silent. The names of Morton and Jackson were, however, associated in an attempt to obtain a patent for the process, which was frowned upon by every right-minded physician and dentist.

It seems that among other after-claimants, one, an estimable physician of Georgia. Dr. Crawford W. Long, awakened to the fact, only so late as 1849 (three years after anæsthetic inhalation by ether—1846—had been in universal practice), that it would be well to record in some medical journal the statement that he had "used ether by inhalation in surgical operations on several occasions" (as many as five in the course of as many years) prior to 1846. He accordingly, in December, 1849, published "an account of the first use of ether by inhalation as an anæsthetic in surgical operations." This communication, tardy as it was, Dr. Long very properly made in simple justice to

PLATE 2.

Wm. T. G. Morton M.D.

himself. No special attention was paid to it for reasons which will soon become apparent. He seems, indeed, merely to have desired to place himself on record in connection with this subject in 1849. In 1877 this forgotten record is dragged from its obscurity and amplified and adorned into a patent of discovery. The interests of truth will be best served by referring to Dr. Long's original text. One quotation will establish these points. We shall be brought straightway to the very pith of the case by the following summary, as given by himself, in his communication of 1849, already referred to: "The result of my second experiment in etherization was such as led me to believe that the anæsthetic state was of such short duration that ether would only be applicable in cases in which its effects could be kept up by constant inhalation during the time of the performance of the operation. Under this impression, up to January, 1847, I had not used ether in but one case, in extracting teeth, and thus deprived myself of experimenting in the only class of cases which are of frequent occurrence in a country practice." Now, in the first place, the remarkable admissions contained in this sentence would be valueless if any subsequent experiments had taught Dr. Long more than he here enunciates; but he never, of himself, learned more than this—for he distinctly states that he "was under the impression" embodied in this quotation until January, 1847, three months after the announcement of universal and practical anæsthesia in 1846.

The writer still holds to the opinion expressed in his earlier editions, that the safest systemic anæsthetic in prolonged and capital operations is ether, and in this opinion he is upheld by the majority of surgeons, by a committee of the British Medical Association, the *British Medical Journal*, also by the chief journals of the United States. (See Conclusion.)

It is unfortunately true that at the present day ether deaths occur more frequently from carelessness in administration and proportionately larger amount used than in years gone by.

Sudden deaths were extremely rare, but are now more frequent, owing, we think, to, first, the use of a more powerful ether, and, second, to carelessness in employment, as in the case of a recently reported death, when six ounces were employed

for a non-capital operation, which could have been performed under a local anæsthetic.

One reason for employing so large a quantity of ether is the strong desire to etherize the patient as rapidly as possible, and neglect to use the minimum quantity to keep the patient profoundly anæsthetized.

In ether it is almost always the danger from interruption of the respiration, and secondarily interference with the heart's action, hence there is a chance for the use of artificial respiration. In such cases elevate the feet and lower the head until the face flushes and shows restoration of the heart's full action.

Chloroform.

Discovery of Chloroform.

This valuable anæsthetic agent was first discovered in an impure state as "chloric ether," in 1831, by Samuel Guthrie, of Sackett's Harbor, N. Y. Little notice was taken of it until Soubieran and Liebig produced it in a pure state by the action of chlorine gas upon methyl chloride, a year after the discovery of the anæsthetic qualities of ether (1847).

Professor Simpson, of Edinburgh, by his courage, brought chloroform into use upon the suggestion of Dr. Waldie, a chemist of Liverpool. Simpson found by experiment that a much smaller quantity of chloroform than of ether was required to produce profound anæsthesia, the former being more prompt in action and more agreeable to the patient both in taste and odor.

Chloroform had, however, a great drawback in general use as an anæsthetic, in that it would without warning cause very sudden death from cardiac syncope.

The True Value of Anæsthetics.

No one can form, even at the present day, a just estimate of the true value of the various anæsthetics or express in words their wonderful and extended application to the relief of human suffering. To the general surgeon it gives the opportunity of operating in grave cases of disease and injury, without which

the death of the patient would be inevitable. It also affords, by the immediate relief from pain, the power to manipulate the broken or injured parts with facility, and thus obtain a correct diagnosis in the most obscure diseases and painful accidents.

To the obstetrician and gynæcologist it is most valuable in assuaging the terrific pain of labor, and makes the dreaded instrument a blessing in disguise. In the diagnosis and treatment of abdominal diseases it gives precision and almost marvellous results, and in the removal of large masses or ovarian tumors great freedom from the dreadful effects of shock to the nervous system. For the ophthalmic surgeon the local anæsthetic reduces the sensibility of the eye so that it can be touched and cut with impunity, and severe and dangerous operations can be performed upon this delicate and sensitive organ without pain and with much less risk.

Again, in the removal of foreign bodies from the eye or ear, particularly in children, by the use of the local anæsthetic all spasm is relieved and the act is accomplished without injury.

The profound sleep gives a most favorable opportunity to the aural surgeon to perforate the membrane tympani, cut the minute tendon of the tensor tympani muscle, perforate the mastoid cells, open abscesses and remove intramural tumors from the brain.

Theories of the Manner in Which Anæsthetics Produce Their Effects.

At the present day certain theories are ventured to explain the effects of general anæsthetics on the system:

1. That they act by retarding oxygenation and induce a true narcosis.

2. That they produce actual changes in the blood, thus causing secondary inhibition of the function of the sensory nerve cells.

3. That they merely bring about cerebral anæmia, from which condition anæsthesia results.

4. That they have a direct action upon the nervous tissue itself.

5. There is no true similarity between the phenomena of true

anæsthesia and those of asphyxia; the conditions are not identical, and when asphyxia takes place, which occurs with all anæsthetics, it is a complication which is to be avoided, especially with nitrous oxide, ether and chloroform.

In regard to the second theory, it is admitted that certain anæsthetics, like chloroform and ether, produce changes in the blood and in the heart, and if carried too far these changes will become permanent; they, however, are neither necessary nor essential to the production of true anæsthesia.

It is somewhat remarkable that the fate of almost all the claimants to the discovery of anæsthesia was so tragical. We have already referred to the sad end of Dr. Wells. Dr. Charles T. Jackson died at Somerville, Mass., after a seven years' illness, a disappointed man, although receiving an honorarium and medal from the Government of France. Morton, having been reduced to poverty during the long twelve years in which he endeavored to wring from Congress and the courts recognition of his rights, died suddenly in New York City, in 1868, of cerebral congestion, brought on, it is said, by reading a work attacking his claims. How much more fortunate was Professor Simpson. of Edinburgh, whose introduction of chloroform won for him a baronetcy, the highest honors of his profession, a statue in Edinburgh and a memorial bust in Westminster Abbey!

Long was the happiest. He died, comparatively little known, in 1878, a poor man, though now his statue, with that of Oglethorpe, will represent Georgia in the National Gallery at the Capitol. Owing to the bitter controversy that resulted from the claims of Wells, Morton and Jackson to the discovery of ether anæsthesia, a monument was erected in Boston with only the following inscription:

"To commemorate the discovery that the inhalation of ether causes insensibility to pain. First proved to the world at the Massachusetts General Hospital, in Boston, October, A.D. MDCCCXLVI."

Cocaine.

After the prolonged use of the systemic anæsthetics, ether, chloroform and nitrous oxide, from 1846 to 1896, it has been

found that with the free use of chloroform and ether, deaths would follow their use in the hands of even the most experienced, careful and conscientious physicians and surgeons all over the world. The deaths from the third agent, nitrous oxide, were comparatively few; but owing to the cost and the mechanical apparatus required for its use, even with the addition of oxygen, but few surgeons would employ it in protracted operations. It was still a desideratum to find a *local anæsthetic agent*, that would be safe and could be employed in more or less extensive operations. In 1855, Gaedeke discovered in coca an alkaloid to which he gave the name "erythroxyline." This principle was first thoroughly studied by Dr. Albert Niemann, from whom it received the name "cocaine," and he found it to be a most valuable local anæsthetic. The first to use it extensively was Dr. Karl Koller, of Vienna, who found it a local anæsthetic and of vital importance in operations upon the eye. His experiments and observations were received with enthusiasm all over the world, but especially by ophthalmic surgeons.

Like every other new anæsthetic, it was applied in a great variety of methods, but with little knowledge of its true physiologal action and in too strong solutions. We made a series of experiments with the drug, as early as May, 1889, in the laboratory of the University of Pennsylvania, to determine its action, in conjunction with Professor Reichert.

A dog weighing 8 kilo was injected with 1½ grains of Merk's hydrochlorate of cocaine. Pulse 172, temperature 38.9, the amount of cocaine being at the rate of 2 centigrammes per kilo. Without going into detail, there were jerking movements of the muscles, intoxication, the pupils became dilated, balls prominent and hard from increased intra-ocular pressure. In the course of ten minutes, convulsions supervened, both clonic and tonic. When fully under the iufluence of the drug, sight and hearing seemed to be unimpaired until convulsions set in.

In another experiment in a dog, weight 16½ kilo, pulse and temperature were the same. When the dose of the cocaine was doubled and the injection made near the spine, the brain became evidently very much affected and delirium was much more decided, with great excitement. Respiration very much more

rapid, with panting and salivation. Ears thrown back, eyes protruding, balls hard, pupils dilated, with increased heat of body.

The fatal dose in dogs was found by Dr. Reichert to be 0.03 gram per kilo. Subcutaneous injection produced local anæsthesia at the point of application. When taken internally it appeared to act as a stimulant and in large doses had a paralyzing action on the nerve centres. It affects, first, the cerebral hemisphere, next the medulla and afterwards the spinal cord.

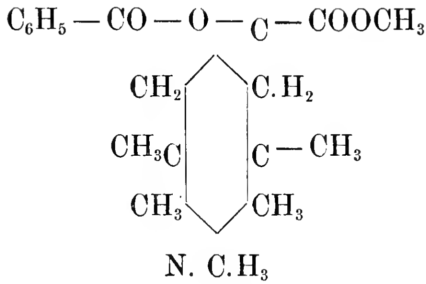
In spite of these and other careful observations. the drug was employed in large quantities and in very improper cases. Gradually, as cases of poisoning took place, and even deaths followed, alarm was taken, and many, from fear, ceased to use it.

In November, 1894, Dr. H. V. Würdemann brought to the notice of the American medical profession his experiments and conclusions obtained by following out Schleich's method and the line of experiments instituted a month before by Schleich, of Berlin, relative to the local anæsthetic properties of water *associated with a minute quantity of cocaine*, morphia and saline water. The success of this new method is due to the way in which the injection is made, as care is taken merely to affect the tissues to be involved in the operation, only a small radius being deadened by each quantity of solution. No tissue, either of bone or muscle, has yet shown resistance to aqueous anæsthesia if rightly followed.

Cases are already being reported from parts of the United States, and so far the reports seem to be warmly favorable to the adoption of the new method in all surgery, at all events, in even the gravest class of operations.

Eucaine Hydrochlorate.

This is a new local anæsthetic, discovered in 1896, and a substitute for cocaine, and it is stated by a number of good authorities to be free from some of the objections to cocaine. Like cocaine, eucaine is the methylester of a benzoylated oxypiperidin carbonic acid. Its constitution is represented by the formula:



The hydrochlorate of eucaine, which is to replace the hydrochlorate of cocaine, has the following chemical constitution :

$$C_{19}H_{27}No_4HCL.$$

This new compound differs from cocalin* in that a methyl group is substituted in it for a hydrogen atom which is formed by the action of ammonia upon acetone.

* Cocalin is poisonous.

PART SECOND.

NITROGEN MONOXIDE—NITROUS OXIDE GAS ($NO—N_2O$).

CHAPTER III.

Nitrous Oxide Gas—Mode of Preparation and Chemical Composition—Gasometer and Inhaling from it—Liquid Nitrous Oxide and Inhalers—Anæsthesia from Nitrous Oxide—Physiological Action of Nitrous Oxide Gas—Experiments with the Gas—Additional Facts in Reference to the Physiological Action of Nitrous Oxide.

Nitrous Oxide Gas, its Mode of Preparation and Chemical Composition.

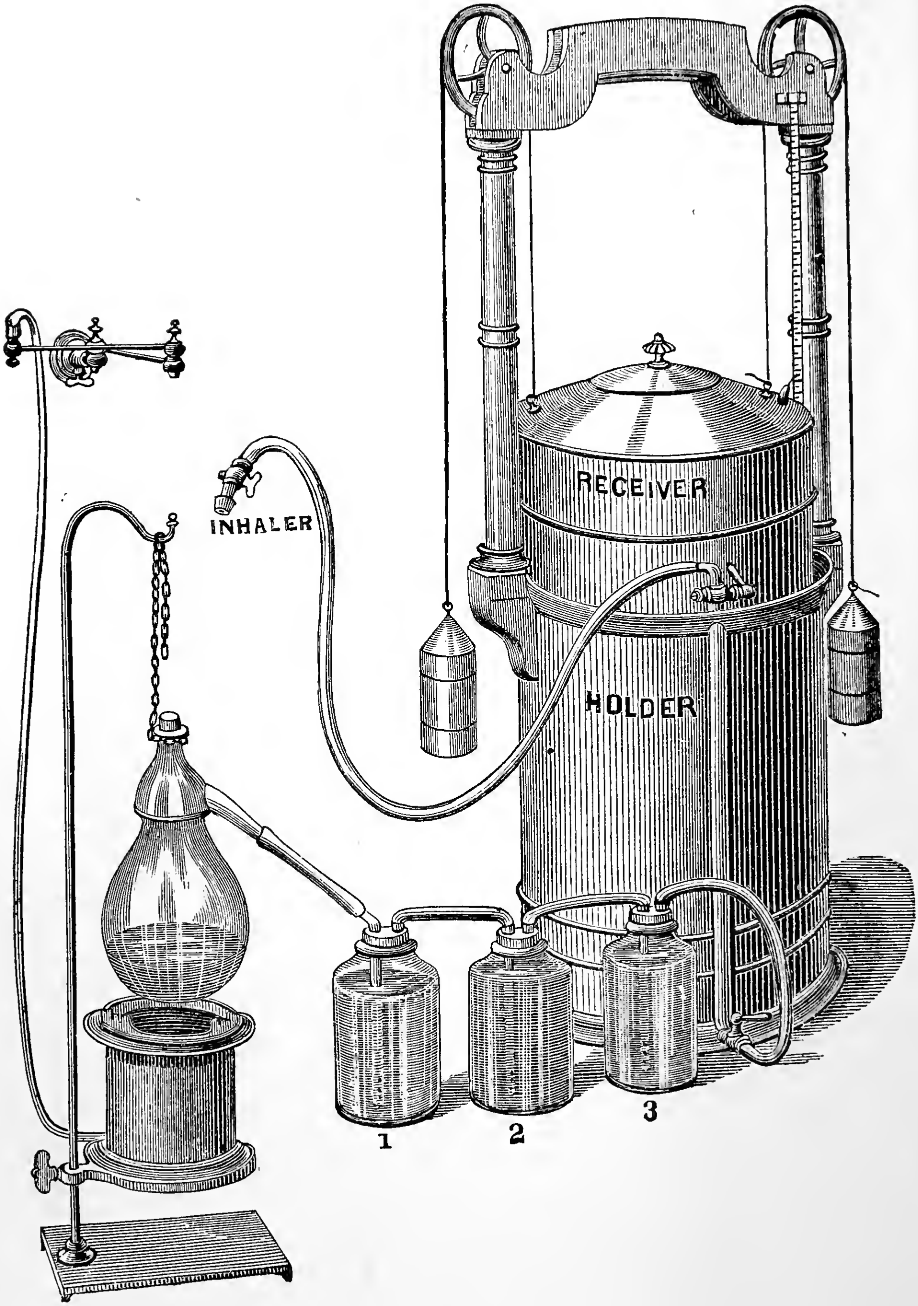
As nitrous oxide gas was the first agent employed under the title of an anæsthetic we have placed it first on the list in this edition. It has powerful claims to our notice, first, that so few deaths have followed its careful and conscientious use, and, second, it is the most extensively employed of any one of the systemic anæsthetics.

Nitrogen monoxide, or nitrous oxide gas ($NG—N_2O$) is prepared from the nitrate of ammonia (this is now obtained from the waste products of gas works by the action of nitric acid); it is then purified, which process resolves it into the gas and water, thus:

$$NO_3NH_4 = O = N_2O + 2\ H_2O.$$

The nitrate of ammonia is a crystalline salt, but for convenience of introduction into the retorts should be in granulated form, which can be obtained of the manufacturing chemist.

PLATE 3 (Figs. 1, 2, 3).

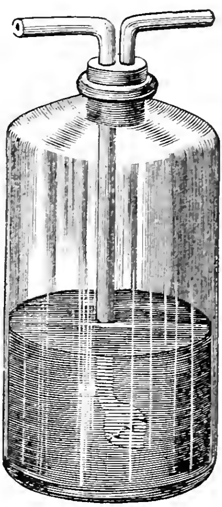


Gasometer and Inhaler.

Gasometer for Preparing Nitrous Oxide Gas.

The most important apparatus to be furnished is a convenient reservoir or gasometer (this can be made by any intelligent tinsmith, as the dental depots do not now supply them, furnishing only the washing bottles, etc.), an illustration of which is seen at Plate 3, with Nos. 1, 2 and 3 bottles. These can be obtained from the dental depots. Care is required in the selection of the bottles for washing and purifying the gas. Plate 4 represents the best form, which is furnished with perforated rubber cork and glass tubes bent at right angles. The long tube which dips into the bottle is pierced with small holes at the bottom nozzle; this agitates the gas, and so insures its more thorough washing. In purifying the gas some employ a solution of sulphate of iron in bottle No. 1, and pure water in the other two. To remove chlorine gas, which is sometimes present, and can be noticed by its green color and its irritating action upon the respiration, a small stick of caustic potash may be added to one of the bottles containing the pure water. When no chemical agents are employed in the purification of the gas it should be well washed through fresh water and allowed to stand for some hours over the water in the gasometer, to remove any impurities that may have passed over. Plate 5 represents the gasometer in position. The holder is first filled with water to within one and a half or two inches of the top; while this is being done take off the weights and open all the spigots, to allow the air to pass out, and the receiver to remain in position.

PLATE 4.



The long pipe of bottle No. 1 must not dip under the water, for the tubing thereby becomes choked with dense vapor and the free passage of air is interrupted.

Into wash-bottle No. 2 place about four ounces of sulphate of iron, and add sufficient water to cover the end of the dip-pipe, about one and a half to two inches.

Into wash-bottle No. 3 it is unnecessary to place anything but fresh water; yet some, fearing the chlorine, add a stick of caustic potash. Sufficient water should be employed to cause the pipe, which dips into the water, to sink the same depth as it does in No. 2.

When bottles are prepared, connect them with a piece of rubber tubing and to the spigot of the gasometer. If they are arranged properly a current of air blown into the tube, intended to connect with the retort, will cause the water to bubble in the wash-bottles Nos. 2 and 3, and if the spigot is open the receiver will commence to ascend.

Having the bottles in readiness, and properly connected, place the quantity of nitrate of ammonia which will be required into the retort (one pound of granulated salt will produce about thirty gallons of the gas).

There is a stove-like arrangement heated by gas-burners, with a sand-bath for holding and heating the retort. Connect the retort with the long pipe of the first bottle by the rubber tubing, and then open the spigot of the gasometer.

The heat must be applied gradually, first to melt the ammonia, about 226° F., and then to cause it to boil and give off gas at 460° F. to 480° F. until it is nearly all decomposed. When the gas has ceased to come over take a cloth and disconnect the retort from the tubing and close the spigot of the gasometer.

The inhaling-tube is attached to the spigot at the top of the holder. There is a register which shows the number of gallons of the gas in the receiver. When the holder is filled, close the spigot and arrange the weights; it is then ready to receive the gas. The wash-bottles are placed as represented in Nos. 1, 2, 3, which are connected one with the other, and to the retort and gasometer, by means of rubber tubing. The first bottle, No. 1, is placed next to the retort, and is simply used to catch the drip resulting from condensed vapor.

The water and solutions contained in the wash-bottles should be changed once in a month. When nitrous oxide gas is thus obtained it is colorless, almost inodorous and of a sweetish taste. The chemical composition is as follows: Nitrate of ammonia

resolves itself into nitrous oxide gas and water; thus $NO_3NH_4 = N_2O + 2\ H_2O$. The heat necessary to cause active evolution of gas is stated to be 460° F., and this heat should be kept up, else a portion of the salt will sublime. The heat should never be allowed to rise above 482° F., as the nitric oxide is apt to be given off in the form of an orange-colored vapor. In infinitesimal explosions, nitric oxide is a dangerous impurity, as it cannot be breathed unless very much diluted, and tends to suspend respiration and produce spasm of the muscles of inspiration. To determine the proper temperature a thermometer is prepared which can be passed into the cork and into the retort, so that no risk from superheating need be incurred by the introduction of poisonous materials into the gas.

After the gas is made it should stand over water for a few hours, not longer, else endosmotic action will take place and weaken the gas before using. This will do little toward insuring absolute purity of the gas; neither will washing it through the solutions of iron and potash purify it perfectly. Should there be chlorine present (which is the poisonous element) in the nitrate of ammonia no amount of washing through solutions will obliterate it. The ammonia should always be tested before using; this is done by dissolving about a teaspoonful in half a tumbler of distilled water and applying a few crystals of nitrate of silver. If the ammonia be pure the solution will remain perfectly clear; but should chlorine be present it will show a clouded appearance and impure ammonia, which must be discarded altogether.

Iron Retorts for Making Protoxide of Nitrogen Gas.

Nitrous oxide for dental operations has come into general use, and dentists making their own nitrous oxide must have doubtless met with great difficulties in consequence of the breaking of the glass retorts. To obviate this inconvenience, the idea has been suggested to use iron retorts. One can be made of rolled iron. 14 inches long by 6 inches wide, outside measure, of a quarter of an inch thick, the joints being brazed together and perfectly air-tight. The bottom of the bottle is convex outside and concave inside, and the top opening is one

inch wide, with a threaded screw inside the mouth of the bottle. To this is attached a tube two feet long with a threaded screw to enable the unscrewing of the tube in order to put the nitrate of ammonia into the bottle. The iron tube is bent at a curve just above the mouth of the bottle, and is two feet long, and the other end of the tube being on a level with the mouth of the bottle, the bottle can be either suspended or placed over a gas-burner or on a fire and the receiver remain in position. The iron retort must be lined with porcelain. All gas must be purified before being employed, by the same method as above directed.

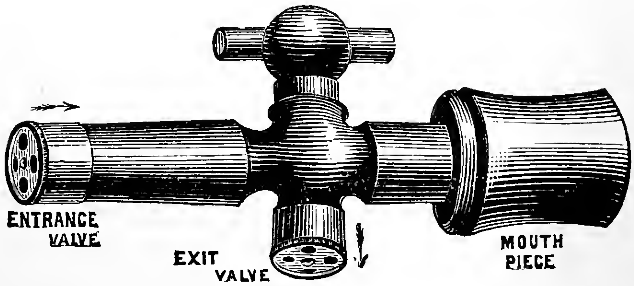
Inhalers.

Next to pure gas, a perfect inhaler is most essential to the successful administration of nitrous oxide.

Thomas' Nitrous Oxide Inhaler.

The Thomas Inhaler, Plate 5, used with gasometer, is turned from a piece of vulcanized rubber, eight inches long by three inches square, leaving the mouth-piece one inch and a half

PLATE 5.



across. The diameter of the opening is a little more than one-half an inch with stop-cock in the centre, in which is the inhaling valve. This is constructed of a simple piece of rubber dam secured by a pin to a stopple, in which are three oblong apertures which have the inhaling valve at the extremity of the inhaler. The aperture, being of sufficient size, is made so as not to obstruct the free passage of the nitrous oxide gas. The

valves are three-quarters of an inch in diameter, and the stopple is of vulcanized rubber.

It must have a tube large enough to admit the gas so freely that the most nervous, as well as patients with weak lungs, can inhale through it without exertion, and it must be perfectly air-tight.

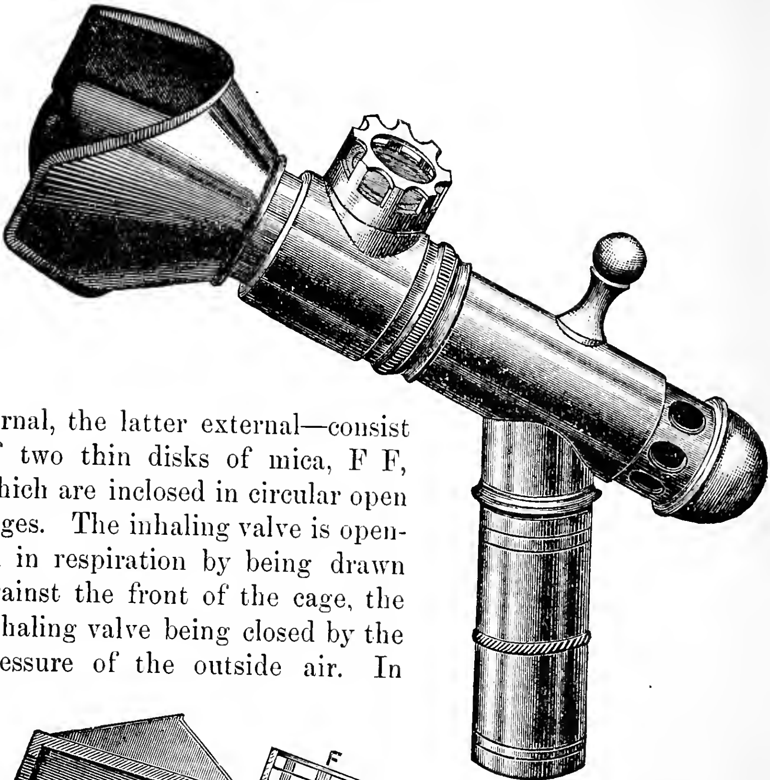
Some inhalers are so constructed that it is only by using great effort, that patients can supply air to the lungs to the amount of their natural capacity, causing them to struggle or go into the anæsthetic sleep with such feelings of suffocation and depression, that they will drift into dreams of the most frightful character, and become almost unmanageable in their excitement.

Nitrous Oxide Inhaler.

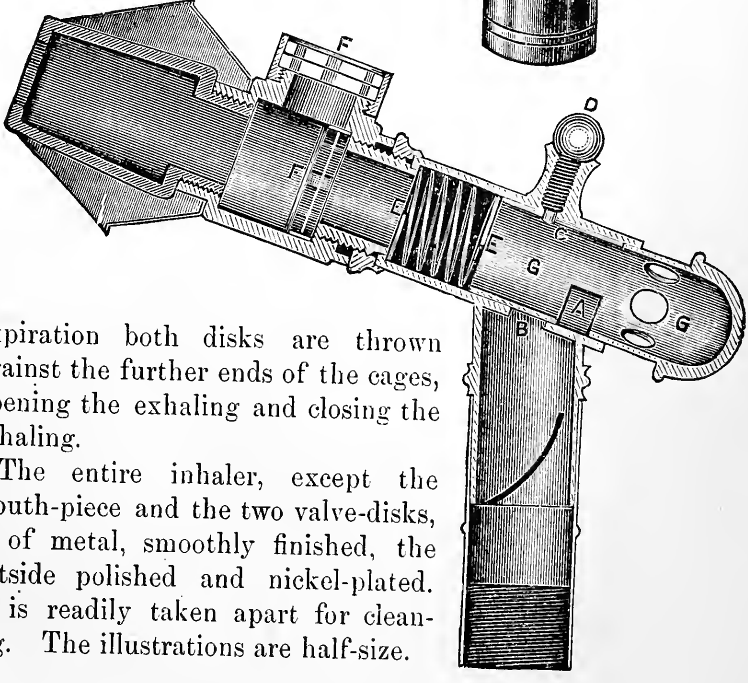
This inhaler* is the simplest, cleanest, most convenient, most effective ever used for the administration of nitrous oxide. It is almost entirely automatic in its action, and requires the use of but one hand, the inlet valve being opened by a slight pressure of the thumb, so that the gas can be turned on without the patient's knowledge. Upon the removal of the pressure, the valve closes automatically and shuts off the gas.

The sectional view shows the internal construction. An opening, B, underneath the body of the inhaler admits the gas through a similar opening, A, in a sliding tube, GG, fitting inside of and projecting beyond the rear portion of the main body. The projecting portion is perforated for the admission of air, and its outer end is closed by a cap. At the inner end of the sliding tube is a coil spring, E E, abutting against a shoulder in the body of the inhaler. This spring holds the sliding tube in the position shown in the cuts, closing the inlet, B, when the gas is not being used. Pressure on the cap compresses the spring, closes the perforations for the admission of air, and brings the opening A over B, affording a free flow of gas to the mouth-piece through the inhaling valve. The sliding tube is prevented from rotating by the screw-pin, D, which works in a slot, C. The inhaling and exhaling valves—the former in-

* The S. S. White Co.



ternal, the latter external—consist of two thin disks of mica, F F, which are inclosed in circular open cages. The inhaling valve is opened in respiration by being drawn against the front of the cage, the exhaling valve being closed by the pressure of the outside air. In

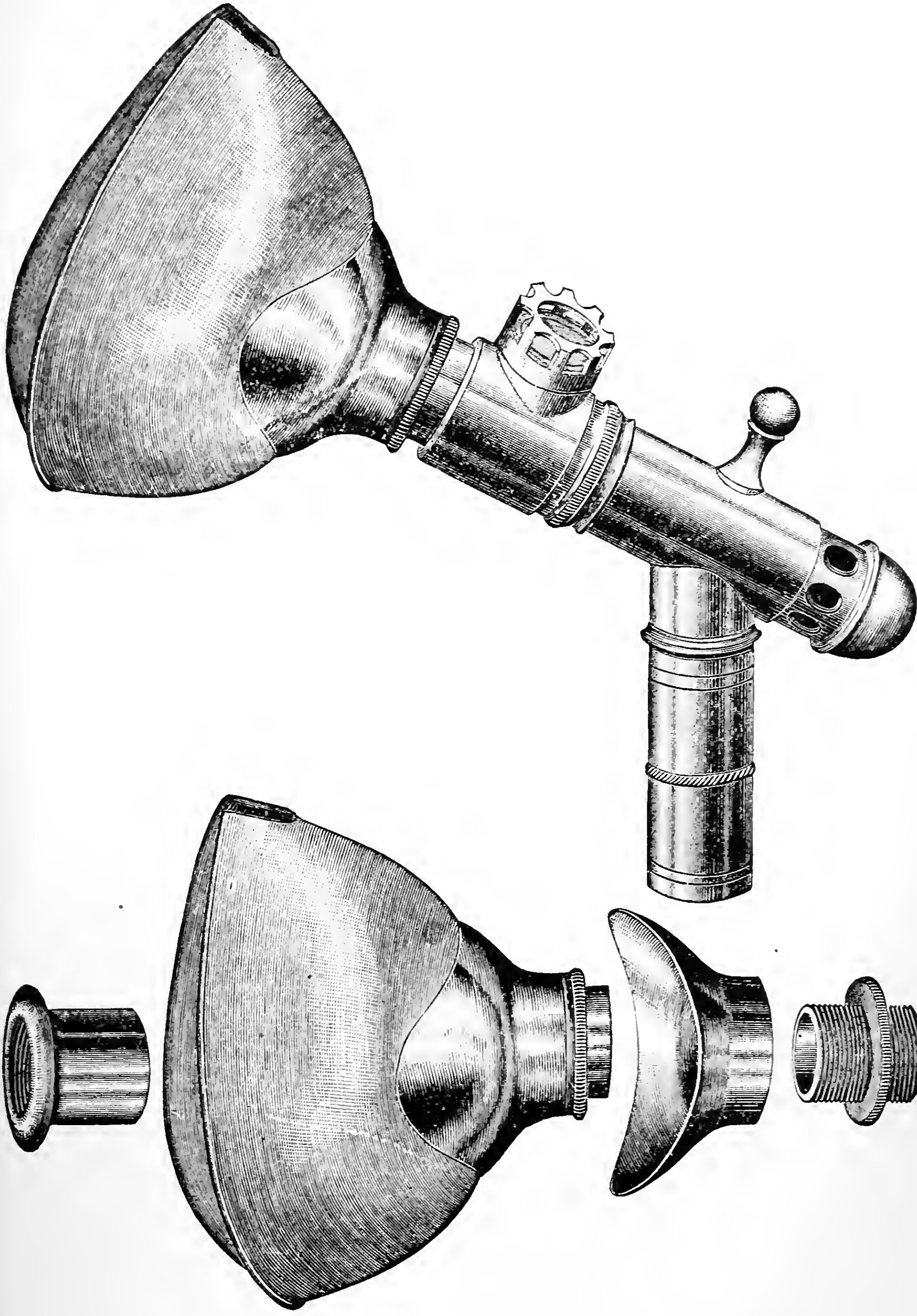


expiration both disks are thrown against the further ends of the cages, opening the exhaling and closing the inhaling.

The entire inhaler, except the mouth-piece and the two valve-disks, is of metal, smoothly finished, the outside polished and nickel-plated. It is readily taken apart for cleaning. The illustrations are half-size.

Flexible Face-Piece for Inhalers.

PLATE 7.



In this form of face-piece the oval shape is maintained by the peculiar metal fittings, as shown in detail. It can be applied to the No. 1 or No. 3 inhaler.

The inhalers which cover the entire face are sometimes objectionable to delicate patients. It must be remembered that the color of the blood, as shown through the mucous membrane of the lips is one of the principal guides to the condition of the patient during the inhalation of gas, and if they are covered too closely from view by the hood or otherwise, we have lost that means of diagnosis. In instances of hare-lip, or where, from swelling or other causes, the muscles of the jaw become so contracted as to render it impossible to pass the mouth-piece between the teeth, a rubber covering is recommended.

Inflatable Face-Piece for Inhaler.

The inflatable face-piece consists of a soft rubber hood with an inflatable edge-cushion attached to a metal frame, which is screwed into the inhaler. The frame, which preserves the shape of the hood, may be readily detached for cleansing by unscrewing the nut which holds it to the neck of the inhaler. The cushion is inflated through the little tube. The best adaptation to the face is obtained when it is only partially distended.

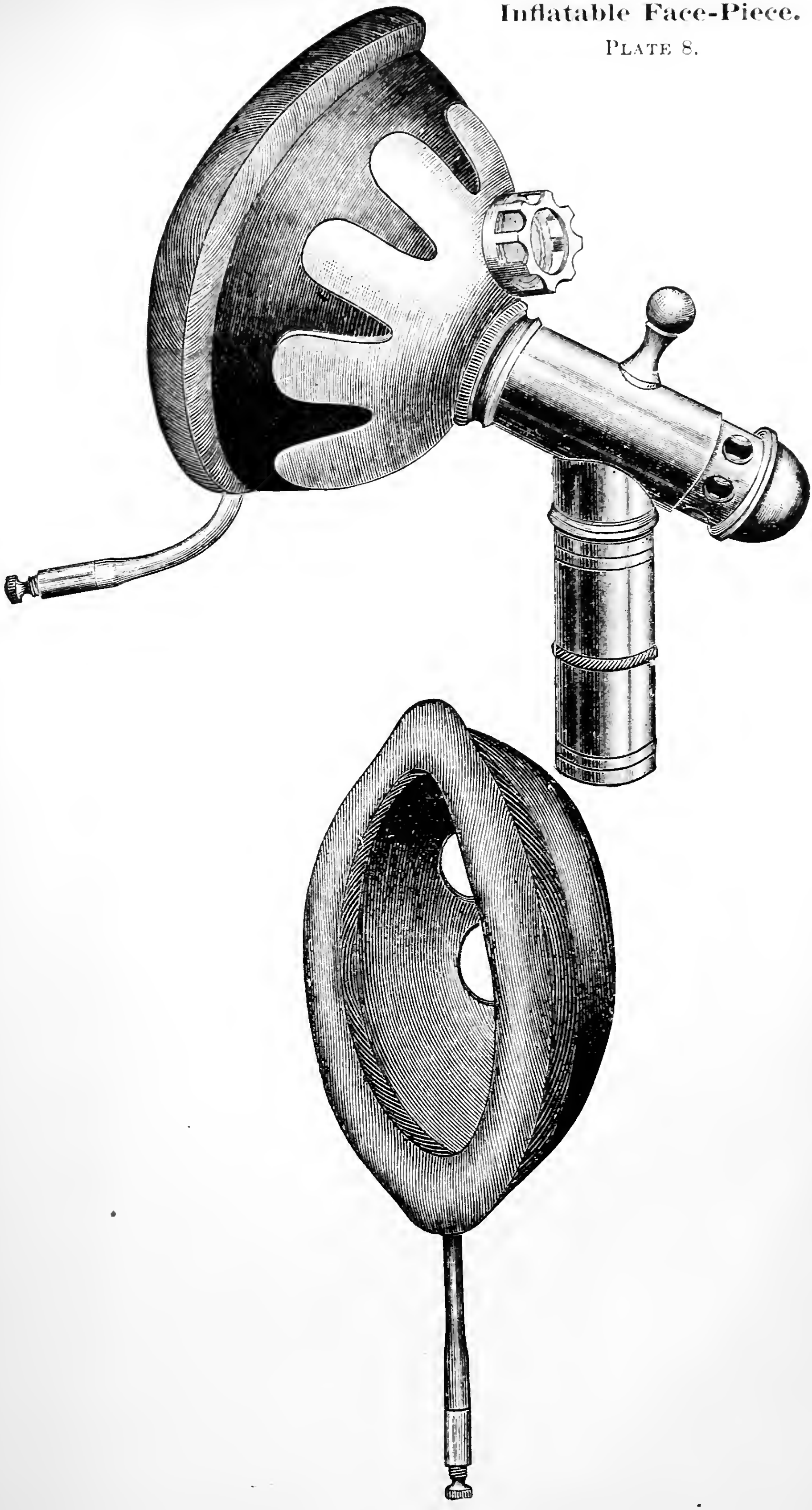
The inflatable face-piece* consists of a soft rubber hood with an inflatable edge-cushion attached to a metal frame, which is screwed into the inhaler. This frame, which preserves the shape of the hood, may be readily detached for cleansing by unscrewing the nut which holds it to the neck of the inhaler. The cushion is inflated through the little tube. The best adaptation to the face is obtained when it is only partially distended.

This is an improvement on a face-piece which has been in use in England for several years. In adapting it to the No. 3 inhaler we have found it desirable to place the exhaling-valve on the frame of the face-piece.

* The S. S. White Co.

Inflatable Face-Piece.

PLATE 8.



An Improved Nitrous Oxide Gasometer.*

An Apparatus for Administration.

The complete apparatus consists of a cast-iron stand (on rollers) for holding the cylinder and gasometer, brass or copper reservoir or water-holder, with bell or gas receiver, guide-rod for same, one foot one-quarter inch rubber tubing, No. 3 inhaler with inflatable face-piece and four feet covered tubing, metal connection for tubing, wood holder for inhaler, two Russia iron jackets (one each for large and small gas cylinders), wheel key and yoke.

The gasometer is very simple in construction, and handsome in appearance. Instead of an unsightly gallows frame for guiding the bell, it is supplied with a nickle-plated guide-rod, before referred to. This guide-rod is marked to show the number of gallons of gas in the bell. The bell has a capacity of eight gallons. It is "balanced," as it leaves our hands, by means of a "float," so that it will sink with the slightest inhalation of gas. The "float" is an annular air-tight chamber slid into the bottom of the bell, with its inner surface surmounted with two screw-caps containing ordinary gun-shot. Should it be desirable to change the "balance" of the bell the "float" can be readily removed and the quantity of shot added to or decreased, as may be requisite. In this event remove the bell from the guide-rod, unscrew the nut which holds the "float" in position and take out the "float."

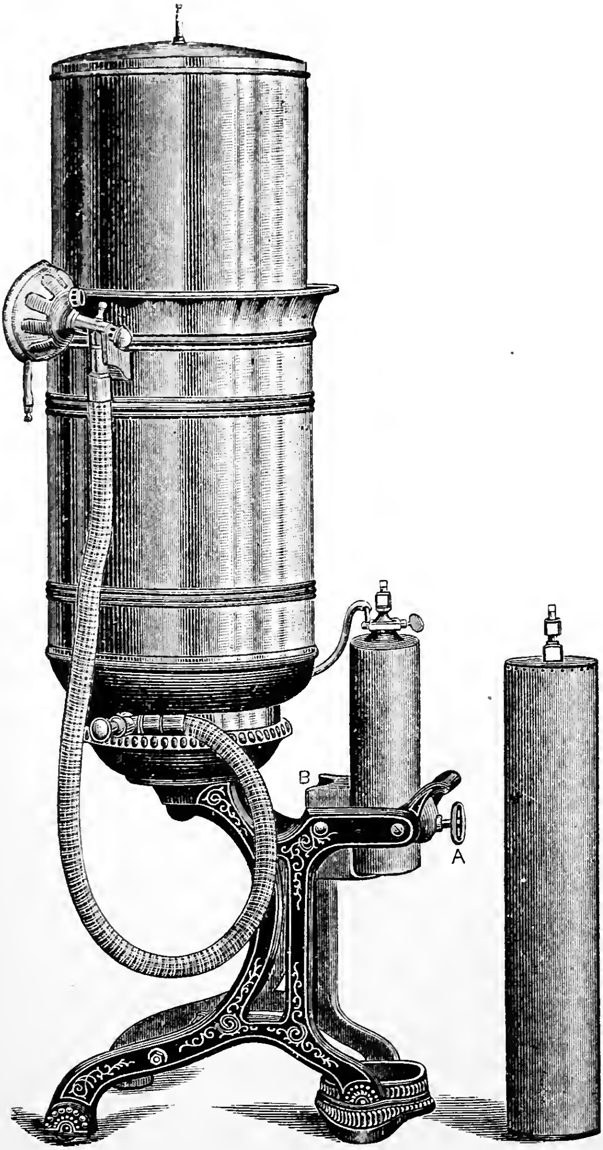
Directions.—Screw the guide-rod I into the bottom-plate inside of the reservoir E, first removing the cork which is inserted to exclude dirt or chips from the packing material, and using say an excavator handle in the hole at the top of the rod to tighten it; attach the wood inhaler holder H. Put the bell F in position, making sure that the guide-rod enters the tube extending through the centre. Open the valve G (it is a piston valve and is to be merely drawn out), and with pitcher or dipper pour water into the tank, filling it to the bead at the base of the flaring rim.

Close the valve G, attach the inhaler tubing to the valve by

* I am indebted to the S. S. White Co. for this improved gasometer.

means of the metal connection, and set the gas cylinder, with

PLATE 9.



its jacket adjusted, in the stand. Observe that large cylinders are set in the socket A at the base of the stand, small ones on

the ledge or flange C at one side of the reversible clamp B. After clamping the cylinder firmly by means of the screw D, and adjusting the yoke, connect it by the rubber tubing to the pipe at the bottom of the reservoir—opposite the valve G, but not seen in the cut—and the gasometer is ready for the admission of the gas.

The valve G is simply a cork plug, which of course has to be pulled out during the administration of gas. It is placed there to prevent the escape of gas through the valves of the inhaler when not in use.

Liquid Nitrous Oxide.

Under a pressure of fifty atmospheres, at 45° F., the nitrous oxide gas is condensed by a pump into a clear, transparent liquid, while the cylinders are kept in ice.

This form has been found so convenient that with many physicians and dentists it has taken the place of the gaseous form. One of the best forms of valve is the Johnson Gas-Valve (Plate 10).

Description.—The seat A (shown by V-shaped dotted line) is made of soft alloy, which easily receives the impress of the plug, and of course the impress must exactly fit the point which makes it. It can be easily operated by a child with a small wrench.

The plug is made in two pieces, B and C, united by a ball-and-socket joint, so that the moment the point touches the seat it is prevented from revolving, and the rotary motion takes place at the ball joint, thus preventing any wear or grinding on the seat.

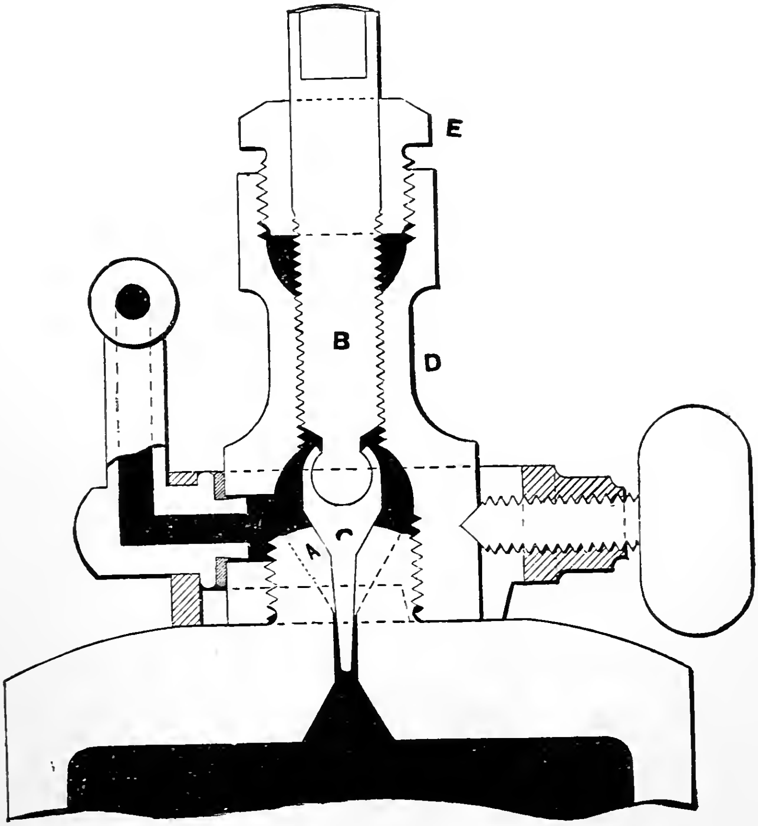
The cock, D, unscrews from the seat, exposing the latter for inspection or repair.

Projecting from the end of the plug down into the gas passage is a long and slightly-tapering point; this nearly closes off the opening, even after the plug is raised from its seat, and there is no annoying rush of gas, even when the plug is raised several turns.

The valve is handsomely finished and nickel-plated externally, and discharges through the yoke in a manner readily

understood from the cut. It is operated by a small hand-wheel or wheel-key, which is provided with a set-screw to secure it in position and thus avoid all danger of its dropping off, which might otherwise occur at the most critical moment in an operation.

PLATE 10.



By the use of a prop one has a fair opportunity to perform the operation to his entire satisfaction; but, without it, there is danger of the patient bruising and possibly breaking the front teeth, by biting so hard upon the mouth-piece, when recovering from the effects of the gas, before the mouth can be opened sufficiently wide to admit of the extraction of a tooth, or any operation upon the mouth.

Nitrous oxide must always be pure to insure success, though some have recommended it after it has stood over water one or two weeks, and even a month ; but it is impracticable. This is obviated in the liquid gas.

A Seamless Steel Gas Cylinder.

This is a great improvement over the old iron cylinder. These cylinders are made without weld or seam, of a single piece of steel of a special formula, stipulated by the S. S. White Co. under the advice of engineers who make steel and its adaptations a specialty, its composition being so proportioned as to insure the metal against hardening to brittleness.

The inspection of the metal and all the processes of its manufacture have been under our direction.

The walls of these cylinders are almost absolutely uniform in thickness, thereby securing the least possible weight compatible with strength adequate to meet the pressure required.

The cylinders measure 4 inches outside diameter by 17 inches long, clear of valve and neck, or $21\frac{1}{2}$ inches long over cap and all, have a capacity for 250 gallons of liquified nitrous oxide gas, or for 75 gallons of compressed oxygen, and have an average weight of 16 pounds without the cap, and $16\frac{3}{4}$ pounds with cap and valve complete.

This cylinder is lighter in weight, stronger and of greater storage capacity in proportion to the weight of metal.

These cylinders will be found bearing our test of 3000 pounds per square inch plainly stamped on the bottom.

They have carried the tests on a number of these to ascertain the strain required to rupture them by hydrostatic pressure, which has demonstrated the fact that it requires from 7000 to 8500 pounds per square inch.

In these tests it was found that the metal possessed a high degree of ductility, as the cylinders swelled so as to increase their diameter very perceptibly to the eye long before bursting pressure was reached.

In employing liquid gas allow a certain amount of space above the liquid for expansion of the gas when subjected to varying temperatures. The S. S. White Dental Manufacturing Co.

has found that in a seamless steel gas cylinder containing 512 gallons of gas, submitted to a temperature of 95° Fahrenheit, the pressure indicated on the gauge was 3200 pounds, and that in the same cylinder, when the quantity of gas was reduced to 452 gallons, and subjected to the same temperature, the pressure was reduced to 1725 pounds to the square inch.

PLATE II.

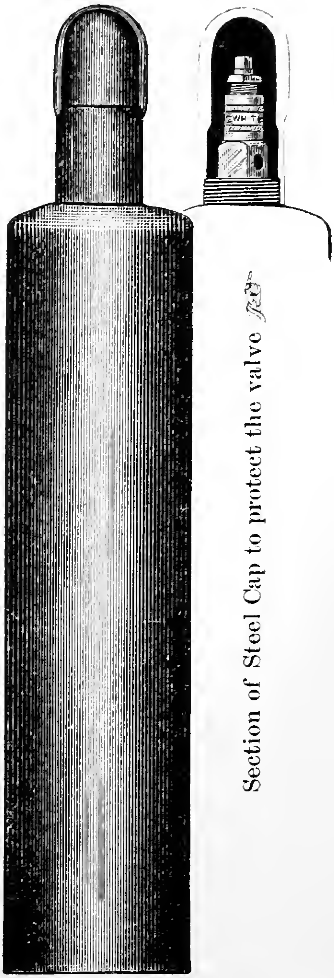


Fig. 1, Cap exposed. Fig. 2, Cap covering the cylinder.

They, for this reason, refuse to put more than from 450 to 452 gallons in 500-gallon cylinders. These 500-gallon cylinders are designed for those who use large quantities of nitrous oxide.

DIRECTIONS. — Use a single leather washer on the coupling-joint of the yoke attachment.

The valve is the only proper and sufficient means of retaining the gas; neither the bag nor the inhalers will prevent its escape if the valve is left open.

After detaching the bag from the cylinder, test the valve to be sure that it is closed. This may be readily ascertained in a very simple way, as follows: Take a little saliva from the mouth on the finger, and gently pass it over the outlet of the valve, so as to form a film over the opening. If, because of imperfect closure of the valve, there is any escape of gas, the film will be forced outward in the form of a bubble. A slight turn more of the hand-wheel and the film may remain stationary or show a tendency to sink inward from the pressure of the external air, proving that there

is no escape of gas. Should any difficulty be experienced, the cylinder should be returned at once.

Cylinders containing gas should never be exposed to heat, as that greatly increases the pressure.

Always close the valve after emptying the cylinder.

The usual quantity of gas given to a patient is from 3 to 5 gallons.

If it is desirable to keep the patient under the influence of the anæsthetic for a prolonged period (as in a surgical operation) the operator has under his control 500 gallons of gas by merely turning the key seen in the cut at the right.

On the bell of the gasometer there is a scale, graduated in gallons and fractions of a gallon, so that the operator can readily see how much gas he has administered.

Another valuable feature of this gasometer is a peculiar water-check or valve, so arranged that though the gas flows freely on the slightest inspiration at the inhaler it is instantly and automatically shut off by the water when the patient stops breathing. This prevents all waste of gas; it also saves the surgeon's or dentist's time at the most critical moment, as he has only, after having administered the gas, to lay aside the inhaler and proceed at once to operate without the necessity of shutting any stop-cock. The stand is so constructed that a small (10-gallon) cylinder can be used while the larger cylinder is being refilled.

We also call attention to the fact that there is no liability to loss of gas from leakage caused by the operator's leaving the valve of the cylinder open, for, if there is such escape from the cylinder, the bell of the gasometer will rise, and the operator having his attention called to the waste will be enabled to correct the difficulty at once.

The gas can be kept for any length of time, and is constantly on hand *and always of the best quality.*

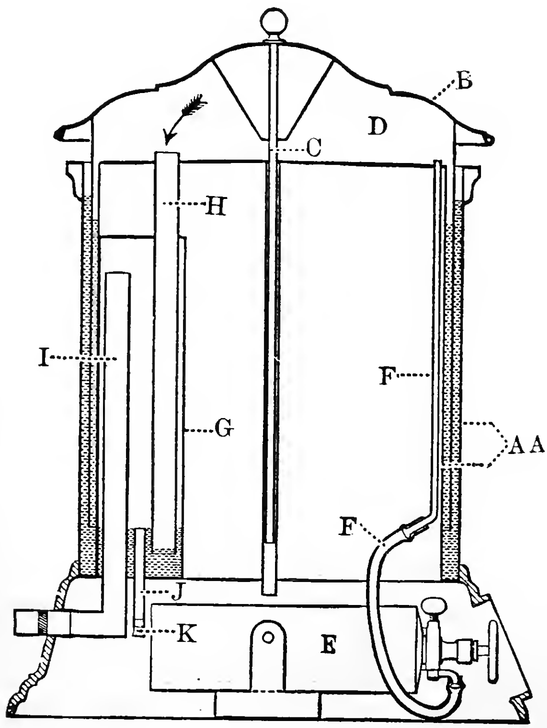
The diagram (Plate 12) represents a sectional view of a nickel-plated gasometer.

Two metallic cylinders, AA, are arranged concentrically to form a water-holding space between their approximating walls, while a third cylinder, having a cover with a guide-rod, C, at-

tached to the cover, is lowered into the water-space as a seal between the cylinders, and to form a gas-chamber, D, at the top. The inner cylinder is provided with a central tubular cavity, closed at the bottom, to receive the guide-rod of the cover.

It is obvious that the chamber, D, will be enlarged or dimin-

PLATE 12.



ished according to the volume and pressure of the gas, which rises to the chamber from the iron cylinder, E, beneath the gasometer, when the valve is opened, through the connecting tube and pipe, FF. The gas is conducted to the inhaler from the chamber, D, through a closed cylindrical water-vessel, G, attached to the wall of the inner cylinder, and provided with an inlet pipe, H, and an outlet pipe, I, which latter is carried to the outside at right angles to the gasometer, and receives the

tubing which conducts the gas to the inhaler. This closed vessel, G, is also provided with a water outlet to overflow, J, and the whole forms a very simple and effective trap for shutting off the gas when not inhaled. In operation it is only necessary, before the cover is placed in position, to pour into the water-space between the cylinders enough water to nearly fill it, and into the inlet pipe, H, sufficient water to overflow the outlet, J, or the trap, the rubber stopper, K, of the latter being removed for that purpose and replaced when the overflow has ceased. Then insert the cover and open the valve of the iron cylinder beneath.

The vacuum in the vessel, G, produced by each inhalation is immediately filled up by the gas passing through the water and upward to the outlet, I. The instant that inhalation ceases the gas is arrested and confined at the water-level in the trap.

Directions for Setting Up and Using the Gasometer.—Unpack carefully the two boxes, removing all the hay from the smaller one before trying to lift the gasometer from the box. Lift the top (bell) of the gasometer clear of the water-tank and set the plated tank on the top of the iron stand, placing it so that the tube underneath, to which the inhaler tubing is to be attached, shall come *exactly* opposite the small hole provided in the iron base. With a cup or dipper fill the annular space in the body of the gasometer (tank) with water to within three inches of the top and pour about a pint of water into the trap through the large tube seen in the top of the gasometer.

To Adjust for a 500-*Gallon Cylinder*.—Secure the wider of the two iron rings in position near one of the feet of the stand by means of the screw provided for the purpose. Keeping the large cylinder horizontal (the stop-cock end may rest on the floor), place the bottom of the cylinder in the ring, being careful, of course, not to drop the cylinder, and observing that the delivery opening of the stop-cock is to the right.

Now slide the other iron ring over the top of the cylinder and elevate this end, at the same time adjusting the ring so that the projection on its side will enter the slot provided for it under the centre of the gasometer, and allow the pin to be put in place, securing it in position. Tighten the set-screws in the

upper ring against the cylinder, using the key sent with the apparatus, so that it cannot turn around when the stop-cock is opened or closed.

To Adjust for a 100-Gallon Cylinder.—It is only necessary to slide the cylinder into its place horizontally through the opening in the side of the iron base, keeping the delivery opening of the stop-cock toward the right, fastening it in position by means of the long set screws which project through the side of the iron base.

In either case (whether a 100- or a 500-gallon cylinder) screw the yoke, which will be found attached to a rubber tube under the gasometer, to its place on the stop-cock of the cylinder, being sure that there is a leather washer properly placed on the union tube. A leather washer will be found attached to every cylinder. *This must be attended to every time a new cylinder is placed in position.*

Draw the small rubber stopper from the end of the tube under the gasometer and allow all the water that will to flow from the tube into a basin or pail, and then replace the cork tight.

Now (and not before) return the bell to its place, being careful to enter the central rod and the graduated scale into their respective guides. After the slight spluttering around the edge of the bell is over, if the foregoing directions have been followed properly, the bell will remain balanced, and a very slight (a few ounces only) pressure of the hand on its top will cause it to settle gradually.

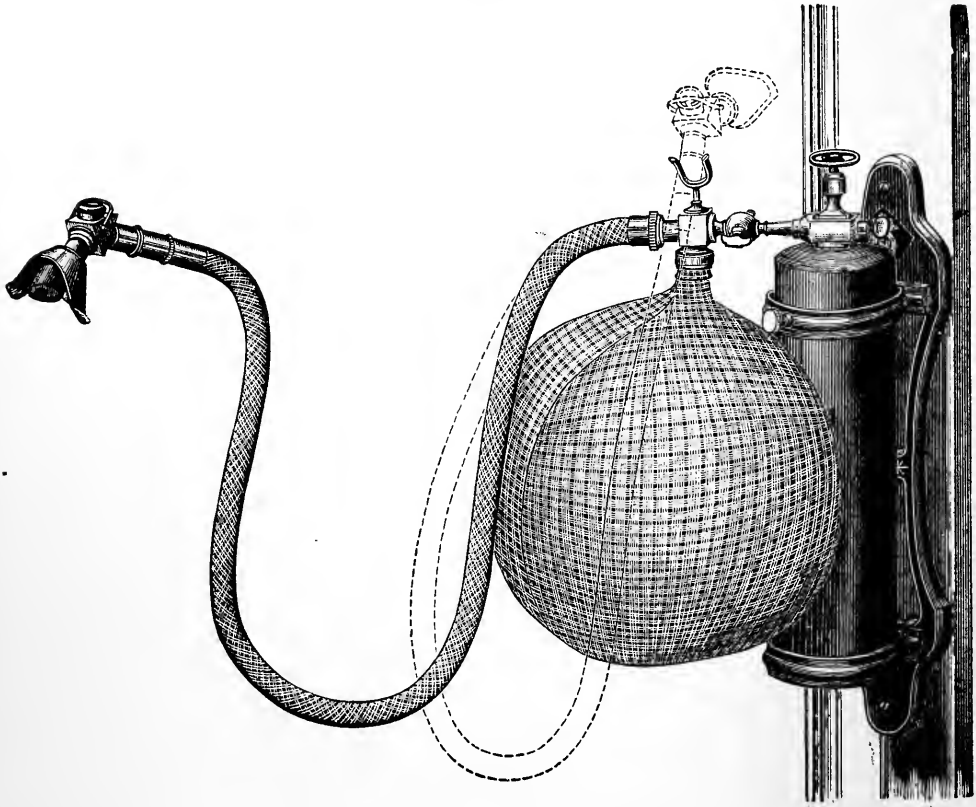
Before letting gas into the gasometer, force the bell entirely down, to remove all air. It is well to let in a few gallons of gas and to force this out also, so as to expel the last traces of air from the gasometer. Now attach the inhaler and tubing to the gasometer by sliding the connection on the end of the tubing firmly to its place through the hole in the side of the iron base; then with the nickel-plated cap cover the opening through which the 100-gallon cylinder goes to its place, and the apparatus is complete.

DIRECTIONS FOR USING.—To let gas into the gasometer, open the stop-cock on top of the cylinder with the key. The stop-cock of both the 100- and 500-gallon cylinders can be reached

through the hole in the centre of the nickel-plated cap mentioned above.

The numbers on the graduated scale indicate gallons and enable one to determine the amount of gas used by each patient; thus, if 10 appears just at the top of the water-tank when beginning to administer the gas, and after the admin-

PLATE 13.



istration 6 stands at the same place, four gallons of gas have been used.

We would suggest that in beginning the use of this apparatus a record be kept of the number of gallons of gas used by each patient.

When liquid gas is used, five gallons is sufficient for ordinary dental operations.

When the ordinary gas as made by dentists is used, an average quantity of about eight gallons is necessary.

After administering the gas it is unnecessary to stop to shut the stop-cock of the inhaler before commencing the operation, as the trap will shut off the gas automatically. It is well, however, to shut the stop-cock immediately upon completing the operation, as otherwise the tubing will fill with air, which will interfere with the next administration.

A large hook will be found under the gasometer, upon which the coiled inhaler tubing may be hung, when it is desired to set the apparatus out of the way.

Cautions.—1st. Do not blow into the inhaler tubing when the inhaler is not in place, as it will derange the water-trap.

2d. If, for any reason, it is necessary to remove the bell from its place, first disconnect the union from the cylinder, so as to admit air to the gasometer, and then raise the bell gently and slowly.

Wall-Bracket for Gas Cylinders.—(Plate 13.)

This is an excellent device for use in offices where the gas is administered frequently. The bracket may be attached to the window casing or other woodwork. As the wall bracket has a yoke attachment, it can be arranged to a stand on the floor of the office. For greater convenience a small cylinder is made, containing bag, inhaler and tubing, in a metal case for carrying by the surgeon to the patient's house.

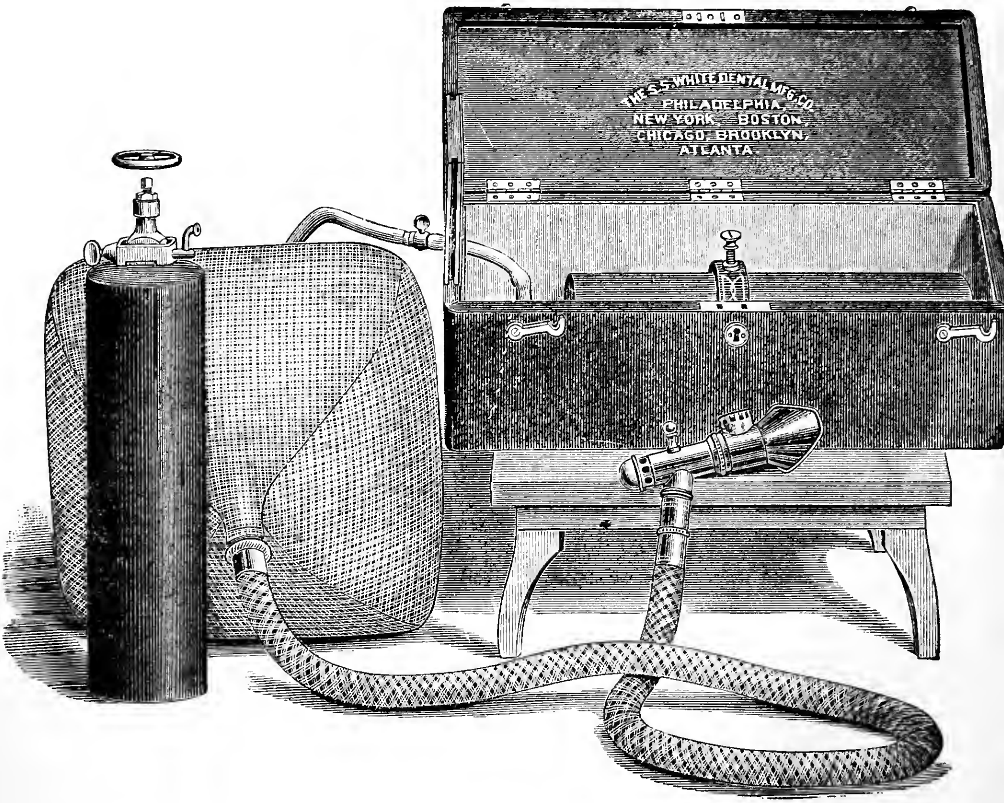
Surgeon's Case.

The complete apparatus consists of an iron cylinder containing at least 100 gallons (usually more) of nitrous oxide, liquefied, to which is attached the necessary tubing, with gas bag and inhaler; the whole inclosed in a stout leather-covered case lined with velvet. The small stop-cock inserted in the tubing between the bag and cylinder enables the operator, after having filled the bag, to shut off the gas and disconnect the bag from

the cylinder, if desired for use where it is not convenient to carry the cylinder.

In manufacturing the surgeon's case particular attention has been given to each and every part, so as to insure not only a

PLATE 14.



complete but the very best apparatus of its kind. These are made for 100-gallon cylinders only.

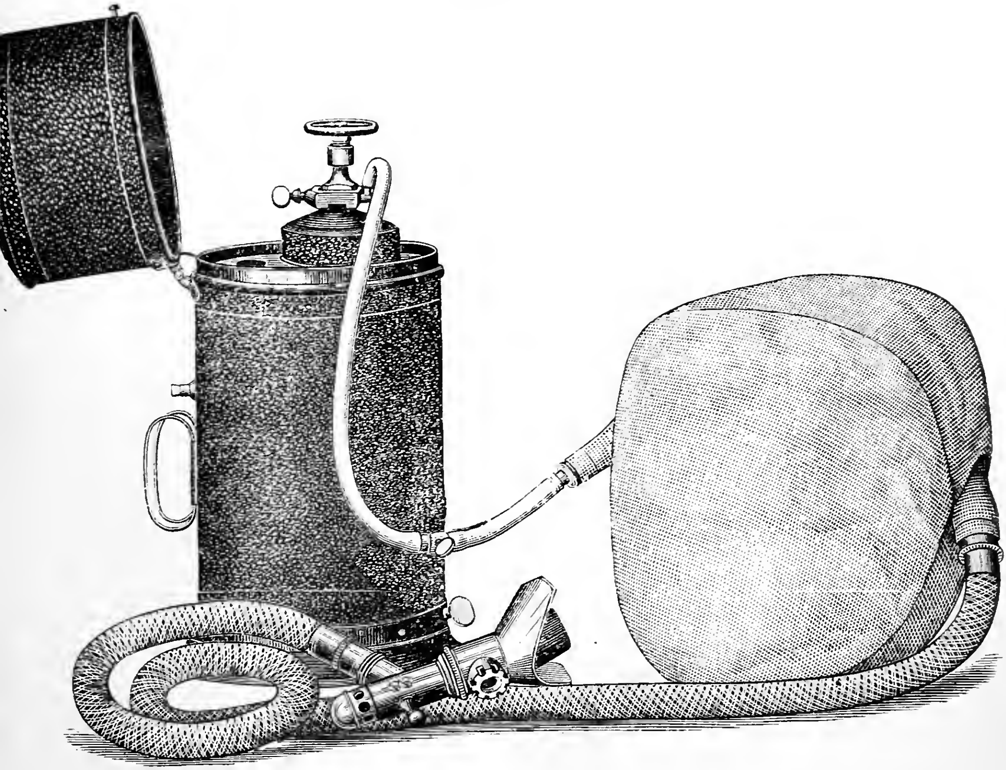
The case is made of well-seasoned wood, lined with velvet and covered with leather, and the mountings are nickel-plated. A stout cast-steel ring, neatly japanned, with a heavy set-screw, clamps the cylinder.

The No. 1 case has a $4\frac{1}{2}$-gallon bag; the No. 2 case a 7-gallon bag.

Surgeon's Upright Case.

In this form of case the cylinder stands on end, which is reckoned by some operators an advantage in permitting a free flow of gas. The small stop-cock inserted in the tubing between

PLATE 15.



the bag and cylinder enables the operator, after having filled the bag, to shut off the gas and disconnect the bag from the cylinder, if desired for use where it is not convenient to carry the cylinder.

These cases are only made for 100-gallon cylinders.

The Proper Method of Administering Nitrous Oxide Gas as an Anæsthetic.

The most important matter is to have an intelligent assistant. It is never safe to be without one. Artificial teeth must be re-

moved, and if the patient is very old or feeble, or there is a fatty heart or diseased lungs, the reclining posture is the safest. The ordinary position is the sitting-up or half-reclining.

The operator stands on one side, and carefully introduces between the teeth a prop of wood or hard rubber, to which is attached a string. The patient's dress, if a female, is opened, and the cravat is loosened if a male. Everything should be done without undue haste. Nor should any noise or loud talking be allowed in the operating-room. The inhaler is then placed between the lips and teeth of the individual to be operated upon, and the nose is clasped between the two fingers if there is no face-piece employed. The gas is now turned on, and the patient is directed to let the mind dwell on some pleasant object—occasionally we have found a few notes from a musical-box very agreeable when the patient is reviving. If there is a face-piece to the inhaler, it is to be gently applied, with just sufficient pressure to prevent the escape of the gas, and the patient directed to make slow and deep breathing. Keep the bag full of gas. Let the assistant watch carefully the pulse and respiration, opening the ingress of the gas during inspiration and closing it during expiration.

Usually it requires from twenty to twenty-five seconds to fill the lungs with the gas; then appears pallor of the skin, with slight darkening of the nails and finger-tips, yet consciousness may be still present, and the inhalation may have to be continued from five to ten seconds longer.

For emergencies, the operator or his assistant should have within reach a napkin to draw out the tongue, an artery forceps to hold it if necessary, nitrite of amyl in case of extreme paleness, but not if much flushed. Above all, to be able to invert the patient so that the blood will reach the anæmic brain, or place him on the floor, opening the windows and performing artificial respiration. Stertor, with slight jactitation, are signs that the patient is ready for operation, and is caused by vibration of the aryteno-epiglottic folds. This comes on after at least a minute, and must not be confounded with the "snoring" of patients who suffer from enlarged tonsils or post-nasal adenoid growths.

The evidence of returning consciousness is the normal color in the face and lips, with a cry or movement of the hands. For long-continued operations in dental surgery, or any surgical operation, a combination of nitrous oxide and ether is one of the best.

The following is the improved apparatus of Clover for nitrous oxide and ether. This is seen in Plate 15.

It consists of a tripod supporting a cast-iron bottle containing fifty gallons of nitrous oxide gas, the bottle being gripped firmly by a screw. The supply is regulated by the administrator's foot, which is placed upon the foot-piece, K. This is provided with teeth which bite into the boot, and enable the administrator, by turning his foot to the left, to open the outlet of the gas. R is the connection between the bottle and the Cattlin bag, G.

The small metallic receiver can be filled with warm water to obviate freezing of the ether in cold weather. The India-rubber tube will be seen to fix on a stop-cock in front of the ether receiver, which latter is suspended by a hook from the administrator's coat. When only gas is to be given, the stop-cock on the ether vessel is put at right angles to the long axis of the bag; when ether is to be used, this stop-cock is turned into the long axis of the bag. The stop-cock in front of the ether-receiver is more conveniently placed just above where the tube is seen to end. The Cattlin bag is so arranged as to allow of pure nitrous oxide, pure ether, or a mixture of these two substances to be administered. The supply is regulated directly by the stop-cocks above-mentioned, but more immediately by an arrangement represented, though not very clearly, at Re. It consists of a semi-circle of plated metal, upon which are engraved at opposite ends the letters G and E. An indicating rod plays upon this by simply shifting the indicator, so that it revolves free of the semi-disc, and the air is inspired. When the indicator points to G, nitrous oxide passes into the face-piece, and as the indicator travels toward F, ether vapor is permitted to mix with the gas until arriving fully at E, when pure ether is inhaled. The cushioned face-piece is used by Clover, and is supplied with a simple expiratory valve.

Should a supplemental bag be used, the face-piece must be provided with an aperture to which this accessory can be adjusted. The stop-cock in this arrangement is kept shut until the residual air of the lungs is presumably exhausted, when it is opened, the finger placed upon the expiratory valve, and

PLATE 16.

the patient allowed to breathe backwards and forwards into the bag.

When desirable, it is a simple matter to convert the Cattlin bag into a supplemental bag (for oxygen gas) by placing a finger upon the expiratory valve, and so causing the patient to expire back into the Cattlin, as well as inspire from it.

Where a gasometer is employed, as in the case of Dr. Thomas, of Philadelphia, and others, a modification of the above apparatus may be used.

A long tube screws on to the efferent pipe of the gasometer, conveying the gas to a bag of two or three gallons' capacity. This may be connected directly with a face-piece, or conveyed to it by another length of tubing, and, by using a three-way cock, it is easy to combine this apparatus in gear with Clover's smaller ether inhaler.

Attachments for gas cylinders have been devised in this country by Lewis, of Buffalo, and Dr. A. M. Long, in which the gas is made to combine with the vapor of other anæsthetics, such as chloroform, ether, etc. The latter has a combining-chamber, through which the gas passes from the cylinder on its way to the gasometer. There is a receptacle for the liquid agent. When a handle below is turned half-way round, the two separate tubes meet, and drop by drop the liquid passes into the combining-chamber.

The Physical Properties and Physiological Action of Nitrogen Monoxide—Nitrous Oxide (No—N_2O).

Nitrous oxide gas, when pure, should be free from color or odor. It has a sweetish taste. It is an active supporter of combustion. A taper will burn in it, but the decomposition of the nitrous oxide is due to the high heat, for at the ordinary temperature of the body it is not decomposed. Seeds will not germinate in it, and animals live longer in this atmosphere than in one of nitrogen. During nitrous oxide narcosis, the amount of carbonic acid exhaled from the lungs is only two-thirds of that eliminated before the inhalation. It has, however, the one quality of producing a sense of exhilaration, freedom from pain and true anæsthesia which no other mixture of *nitrogen*, *carbonic acid*, air or hydrogen can produce, proving that the theory of asphyxia is only, in part, the true one, the circulation having been found very differently affected by mechanical or chemical agents than by nitrous oxide.

Nitrous oxide gas should be kept in a liquid state or made freshly, for it is a well-known and recognized fact that if kept over water it absorbs nearly its own bulk. We have before expressed our opinion that when the gas is administered in its pure state, it enters the air-cells of the lungs and circulates in

the blood. In confirmation of our own views, Dr. C. A. MacMunn ("The Spectroscope in Medicine," London, 1880, pp. 73–75) finds that when an animal is killed by nitrous oxide the arterial blood gives only spectrum lines by reducing hæmoglobin, while after chloroform or even ether those of oxyhæmoglobin are very apparent. See Da Costa experiments.

The marked resemblance between the effects produced by nitrous oxide and those resulting from asphyxia were observed by the earlier experimenters with ether, and a few eminent physiologists at once expressed the opinion, and still hold to it, that the physiological action was the same; but at the present day this is not generally entertained.

The following is a summary of the various facts bearing on the subject, *i.e.*, in regard to the physiological action of nitrous oxide.

It would seem that this accumulated evidence is not sufficient to show that the anæsthesia produced by the inhalation of nitrous oxide is not simply asphyxia. Nitrous oxide gas produces in man, even when mixed with air, a feeling of exhilaration and stimulation which would indicate that it is not merely a passive agent, but acts also as a narcotic. The discolored appearance of the patient while under its influence is, to a great extent, due to the accumulation of carbonic acid in the blood, while the addition of a few inspirations of air or oxygen will prevent it.

Nitrogen, when inhaled, acts upon the animal economy solely by the exclusion of oxygen. When nitrogen or hydrogen is taken into the lungs, it gives rise to no feeling of exhilaration, but sometimes to malaise and a sense of impending suffocation.

After death, which has been very rare from nitrous oxide, the following is the condition of the lungs: these organs are found neither voluminous nor collapsed; of a light pink or rose color, and generally with one or more small circular, well-defined ecchymotic spots, usually on their posterior surface.

The lungs are moderately crepitant, and the blood, which escapes from an incision, is more or less full of gas bubbles.

These bubbles will be found in the bronchial ramifications mixed with mucus, and in one or two instances the trachea was filled with rusty, frothy fluid, so common after drowning.

The local effects of nitrous oxide were found to be like those produced by carbonic acid.

They both act upon the blood-corpuscles so as to darken them. The lividity upon the lips and the darkening of the mucous surfaces, seen every day in the operating-room after administration of nitrous oxide, are the result of this action. The inhalation of nitrous oxide is followed by an increased exhalation of carbonic acid until a certain point is reached, when it diminishes.

The conditions which are obtained after the inhalation of nitrous oxide and other anæsthetics are, *first*, to stimulate, then narcotize, then destroy nervous action by (*a*) an interference, more or less marked, with the oxygenation of the blood and the consequent imperfect accomplishment of certain chemico-vital processes; by (*b*) a retention in the blood of a portion of the usual pulmonary exhalations, carbonic acid, etc., these secondary conditions always finally co-operating with the specific action of the anæsthetic in the production of narcosis, the arrest of innervation, and in the suspension of every functional movement for a time, with a rapid return to health. Latterly it has been proven, both by experiment and observation, that the theory which for a time prevailed in the United States, "that nitrous oxide acts upon the blood as an oxygenating agent," is incorrect. No experimental proof has yet been furnished that nitrous oxide is decomposed in the blood or forms chemical combinations with it. It enters the blood as nitrous oxide, and as such is eliminated. It will naturally be inferred from this statement that the presence of nitrous oxide in the blood is not indicated by the appearance (except change of color), as before stated. This was first very conclusively proven by the late Dr. J. H. McQuillen, Professor of Physiology in the Philadelphia Dental College.

The late Dr. F. R. Thomas, of this city, placed his whole apparatus, with a large supply of recently-made pure nitrous oxide gas, at the disposal of Dr. McQuillen and the writer,

and we repeated the experiments in confirmation of the facts: that the gas had no positive poisonous qualities; second, that the blood-corpuscles were very slightly flattened and compressed, but returned to their normal appearance when air was introduced.

FIRST SERIES.—The experiments were as follows: In our examinations of the blood of man and animals, when ether and chloroform were brought in direct contact with it out of the body, under a fifth objective, the discharge of the nuclei and the disintegration of the corpuscles invariably occurred, and in the frog left a result similar to that which is presented in the accompanying drawing (Plate 16) from one of my specimens, wherein it will be observed that the field is occupied by the nuclei, débris of disintegrated globuline and corpuscles, in which the changes of form, size and other characteristics are most striking.

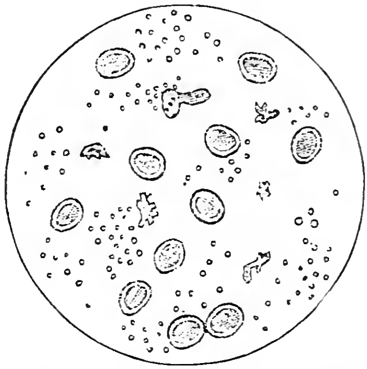
SECOND SERIES.—On placing, however, two glass slides containing frog's blood over watch-crystals, one holding chloroform and the other ether, and covering them with glass finger-bowls for half an hour, thus exposing one to an atmosphere of ether and the other of chloroform, we found, on removing the bowls, and permitting the bloody sides of the slides to remain downward until all ether and chloroform had evaporated, that no disintegration or marked change in the form of the corpuscles was observable under the microscope, on comparing them with the blood of a frog unaffected by an anæsthetic. This forcibly demonstrates the difference between exposure of the blood to *direct contact* to the *vapor* of chloroform or ether even out of the body.

THIRD SERIES.—Over and over again, in the presence of a number of gentlemen, we have placed frogs under the influence of nitrous oxide and examined their blood-corpuscles immediately after without finding any disintegration or change in the form of the corpuscle, except in the hæmoglobin.

It seems to us that the above experiments demonstrate that we are not warranted in denying that this agent acts directly upon the nerve-centres. All the phenomena, indeed, attendant upon their administration, the gradual exaltation of the cere-

bral functions, followed by the progressive impairment and temporary suspension of the special senses, the loss of co-ordination on the part of the cerebellum, and, when the agent is pushed too far, the arrest of respiration and circulation through the decided impression made upon the medulla oblongata seems to favor this hypothesis, in contradistinction to the theory that anæsthesia is due to suspension of oxygenation. In 1887 there was another series of

PLATE 17.



Frog's blood placed upon the slide, and chloroform brought in direct contact with it.

EXPERIMENTS WITH NITROUS OXIDE, by Dr. Turnbull and the late Drs. McQuillen and J. D. Thomas, December.—A large-sized frog was placed under a glass jar holding five quarts of pure nitrous oxide, and kept there sixteen minutes. With the exception of some change in the color of the skin, there was no apparent impression made the first five minutes, as he jumped about when the jar was moved in the pneumatic trough. After that he assumed the position of sitting on the bottom of the jar, and maintained it until removed from the jar, when he was found in a semi-torpid state, with the eyes wide open. On touching them gently, the lids closed and then opened immediately, and the leg retracted on pricking. Two minutes after removal from the jar, he moved slowly about the floor, and ten minutes later hopped from a table on to the floor.

After remaining out for thirty-five minutes, he was again placed under the jar in a fresh supply of gas, and kept there for thirty minutes; on being removed, he presented the same semi-torpid condition, and recovered from it in two minutes. In twenty minutes he was a third time placed in fresh nitrous oxide, and remained there fifteen minutes, with the same result as in the previous trials, the confinement for one hour, in all, to the influence of nitrous oxide not having made any marked

impression on him. Examined under one-fifth objective, and B, eye-piece, the blood-corpuscles presented no disintegrative discharge of nuclei or change of form.

A small-sized rabbit was kept under the influence of nitrous oxide for two minutes, and in one minute after was completely restored to consciousness. He was then kept under the gas for five minutes consecutively, and recovered in one and a half minutes. After this, for twenty minutes, off and on, the animal was under the influence of the gas. In three minutes after removal from it, he was running around the room as though nothing had occurred. The blood, examined under the microscope, gave no evidence of disintegration of the blood-corpuscles. "There is reason to conclude that the inhalation of either nitrous oxide or nitrogen causes an accumulation of carbonic acid in the blood. To produce oxidation of the brain there must be (1) a free current of blood through the capillaries of the brain; (2) the blood must be duly aerated or oxygenized; (3) the blood must be unmixed with any material which prevents or impedes the giving up of oxygen from the blood to tissues."

The Spectroscope and its Relations to Anæsthetics.

It has been stated that "through the agency of the spectroscope has been supplied the missing link to our chain of reasoning. *The shadowy field of theories has been cleared up, the laws governing the relations of anæsthetics in contact with the blood current have been ascertained, and rational progress has been made to insure safe anæsthetics.* I have abiding faith in the progress of chemical science that it will finally point out an agent from the almost inexhaustible materials at its command that will satisfy all surgical requirements—an anæsthetic that, while it will annihilate temporarily all sensation, will leave consciousness and vitality intact."

Now, let us logically apply all these ascertained facts to our case in hand in order to learn how this gas produces its effect upon the economy.

From our experiments we have seen that dogs, when permitted to inhale oxygen at the highest stage of dyspnœa, become rapidly as well as ever after the inhalation of nitrous oxide

gas. A certain effect upon the blood has taken place, often unimportant and transient.

Experiments with the Spectroscope.

These experiments in the course of spectroscopic studies of the blood by the action of reagents were made by the writer and the late Prof. J. G. Richardson of the University of Pennsylvania, Dr. William M. Hodges of New York, and the author's son, Dr. C. S. Turnbull of Philadelphia.

Pigeon, under the anæsthetic influence of nitrous oxide gas. Respiration, 38; pulse—unable to count—from 182 to 210. Was rendered insensible in twenty seconds, and had quite recovered in one minute.

Rabbit.—Blood identical with human blood under micro-spectroscope previous to nitrous oxide administration. Respiration, 138; pulse, 160. Was affected in forty seconds and completely insensible in two minutes. All heart action ceased in one minute and forty-five seconds. There was no change in the blood under the spectrum after death; little or no change in the brain, perhaps slightly anæmic; heart's color natural.

Dr. L. Turnbull and Dr. J. D. Thomas took the gas and went fully under its influence, and their blood showed no change. By passing nitrous oxide through the blood, the death line spoken of was barely visible, but after adding sulphide of ammonium it was clearly seen.

From the above we may conclude that the amount of pure nitrous oxide necessary to induce anæsthesia in man by inhalation does not so affect the blood as to cause any alteration on the two well-known bands in the green portion of the spectrum. In other words, that the micro-spectroscope gives no evidence that radical change in the myohæmatin crystalline is produced by the inhalation of nitrous oxide gas.

Additional Facts in Reference to the Physiological Action of Nitrous Oxide.

Some valuable facts have recently been brought before the profession* in regard to this anæsthetic confirmatory of the

* On the Physiological Action of Nitrous Oxide. By Dudley W.

views which we and the late Dr. I. H. McQuillen have before published in our work as early as 1878.

Nitrous oxide (*a*) is said to produce a state which we term *anæsthesia*—a loss of sensation;

(*b*) it initiates certain emotional states, provoking a sensation of exhilaration and well being; in fact, it plays the *rôle* of a *stimulant;*

(*c*) it gives rise to modifications of the respiratory, and

(*d*) circulatory systems;

(*e*) and provokes marked muscular movements, which may be roughly classed as (i) rigidity or contracture and (ii) jactitations.

These are, speaking broadly, the effects of nitrous oxide upon the mammalian organism, and in attempting to explain them we must ascertain their relations among themselves.

A further fact is, that Dr. Buxton has observed, and his views are in harmony with most of the authorities upon the subject, that during the stage immediately anterior to the loss of consciousness, persons under the influence of nitrous oxide are *hyperæsthetic.*

Nitrous oxide does induce hyperæsthesia. The cerebro-spinal axis—at least as far as sensation goes—is the seat of the changes which nitrous oxide induces, and which culminate in the complete abeyance of consciousness. In this connection he draws attention to the convenience of grouping the brain phenomena, due to nitrous oxide, in three periods: the period before unconsciousness, which he contends is the hyperæsthetic period; the period of unconsciousness, and the period of returning consciousness, in which hallucinations take their origin.

(*a*) The nitrous oxide may either give rise to other bodies by change in its own chemical form; or (*b*) acting purely in a mechanical fashion, it may upset the normal equilibrium of the functions of respiration, and so give rise to accumulation of aërial fluids in the blood, which would normally be excreted.

Buxton, M.D., B. S. Lond., M.R.C.P., Administrator of Anæsthetics in University College Hospital, the Hospital for Women, Soho Square. and the Dental Hospital of London, etc., 1886. Pamphlet, pp. 22, Harrison & Sons, St. Mark's Lane, London.

(*c*) It may act *per se*, and exercise a specific action, just as strychnine or any other body.

At one period it was believed that nitrous oxide acted as an oxidizing agent by splitting up the body or tissues into oxygen and a residuum of nitrogen compounds, and hence came into vogue the Apnœal or Hyperoxygenation theory of Colton. In support of this theory, Stillé and Maisch urge that venous blood is arterialized by shaking it with nitrous oxide, that phosphorus burns in it, and that seeds germinate under bell-jars of nitrous oxide. Zimmerman, whose paper we have not been able to consult, is pledged by Stillé and Maisch to the statement that pigeons and rabbits will recover after being placed in the gas for eight hours. Of course, were such theories true, we should have to admit that nitrous oxide is a respirable gas. In 1872 Dr. Frankland came to the conclusion that nitrous oxide was not *decomposed* during its sojourn in the body, basing his opinion upon analyses made of air expired by rabbits when confined in an atmosphere of mixed air and nitrous oxide.

Jolyet and Blanche, who published their results in Brown-Sequard's "Archives de Physiologie," find vegetables, as well as animals, die incontinently when placed in an atmosphere of nitrous oxide. And in the case of certain seeds, Dr. Buxton has failed to induce germination in an atmosphere of pure nitrous oxide. Of course, combustion will take place in nitrous oxide, provided the heat be sufficient to produce "the mode of motion" in the molecules of the gas, which leads to their disintegration; but experiment has shown that the heat of the blood is insufficient to initiate such a dissociation. Bonwill's suggestion of rapid breathing to produce anæsthesia probably acts rather through the changes it produces in the blood-pressure of the cerebral circulation or nervous exhaustion than by dint of hyperoxygenation. When an animal is killed by nitrous oxide, the blood, if examined within two minutes after death, gives the well-known spectrum of *reduced hæmoglobin*, while the muscles give the corresponding one of *reduced myohæmatin*, but not during the *anæsthetic stage*. Here we are dealing not with nitrous oxide blood effects, but these complicated and probably overridden by asphyxial effects. Another possible

way by which nitrous oxide may be introduced into the organism is by means of the nitrites, thus forming combinations with the coloring matter of the blood, producing oxyhæmoglobin.

Bernard, whose classical work on asphyxia gives the fullest account of that condition, speaks of three forms of asphyxia :

(1.) That arising from inhalation of irrespirable gases which are themselves harmless. To this class many authorities would relegate nitrous oxide.

(2.) That due to poisonous vapors, such as carbonic monoxide, sulphuretted hydrogen, and carburetted hydrogen.

(3.) Asphyxia from want of air, such, for example, as would ensue upon the ligature of the trachea. He subsequently points out, with justice, that asphyxia resulting from inhalation of an indifferent irrespirable gas, and that due to want of access to air, are in fact one and the same condition.

The arterial blood, becoming gradually deoxidized by parting with its oxygen to the tissues, acts upon the medulla respiratory centres; hence follows hyperapnœa. This, in the case of some persons subjected to experiments by Drs. Burdon Sanderson, John Murray and Mr. J. Smith Turner (who caused them to respire pure nitrogen), did not occur for about two minutes after commencement of inhalation.

THE PHENOMENA OF THE SO-CALLED ASPHYXIA OF NITROUS OXIDE NARCOSIS.—In the first place we find a tolerably uniform increase in the number and depth of respirations. Dr. Buxton has not yet succeeded in detecting any excess of expiratory over inspiratory movements. The respirations are, more correctly speaking, simply an exaggeration of the normal, quite regular, but hurried in rhythm and increased in depth. This begins certainly within half a minute—usually within fifteen seconds—from the commencement of nitrous oxide inhalation. The respirations, however, become slower as narcosis proceeds, and finally stertor supervenes, which frequently is followed by a period of complete respiratory calm, no thoracic movements appearing. A few seconds more and respirations are recommenced, and the person passes quietly into ordinary breathing. He has never observed anything which in the slightest degree

resembles the expiratory convulsions one is so familiar with in the case of the lower animals killed by asphyxia. These results will go to strengthen the present theory that *nitrous oxide, pushed to the extent of narcosis*, does not give *rise to circulatory changes at all comparable to those occurring in the course of asphyxia*. The results obtained by the cardiograph in the human subject have not been encouraging, and Dr. Buxton is determined to investigate the exposed hearts of mammals as likely to render a more reliable record. In this connection the experiments of Amory, Krishaber, Goldstein and Kuntz are of interest. These observers found that animals, when subjected to the vapors of nitrous oxide, after a time died. Now it is important to notice that the animals, when made the subject of a post-mortem examination, revealed the usual signs of asphyxial poisoning. But this is, of course, wholly different from death from nitrous oxide. In these animals nitrous oxide narcosis was followed by *suffocation*, *air was excluded*, *and hence asphyxia ensued*. It has happened to skilled anæsthetists to have a necessity of maintaining nitrous oxide narcosis for a considerable time. This has been done by allowing the patient to respire *air* at *long intervals*. In this way a really prolonged narcosis can be effected while we are seeking only to promote the action of nitrous oxide upon the nervous centres.

The true test, and one of great value, is the examination of the blood shed during anæsthesia, performed by the writer in conjunction with the late Professors McQuillen, Richardson and C. S. Turnbull, gas being administered by Dr. Thomas. *We may then conclude that pure nitrous oxide produces narcosis by virtue of other than asphyxiating qualities.*

This gas, then, enters the blood through the lungs and exercises a certain specific action upon the nervous centres. And here we have a ready explanation of an otherwise most anomalous circumstance, viz., that in a certain number of cases, persons evince the utmost toleration of nitrous oxide and resist the nepenthal action for a minute or more. Were nitrous oxide purely an asphyxiant, we should invariably narcotize our patients when replaced by oxygen, but such is not the case—in fact, they are narcotized *before this oxygen is exhausted.*

Nitrous oxide enters the blood by producing an anæsthesia with no combinations, except the broad one between Fraunhofer's D and E lines which represents the spectrum of reduced hæmoglobin. It then passes to the nerve centres as venous blood, plus some stimulating and narcotic-influence, and gives rise to subjective exhilaration. Upon the heart it acts as an accelerator. At this time the inhibitory centres are in a state of at least lessened activity, as is evidenced by involuntary movements, micturition, etc.; later the reflexes are lost. During this stage the blood pressure would appear to be lessened, the action of the heart accelerated, and the respiratory rhythm, at first quickened, subsequently slowed to a standstill. This state of things persists for awhile, and is accompanied by relaxation of some muscles, *e.g.*, the palatine and faucial muscles, while other muscles are the seat of arhythmic clonic and tonic contractions. Following upon this stage we usually meet with the phenomena of recovery. During this period a further stage of excitement appears, and it is commonly associated with hallucinations—sometimes pleasant, sometimes extravagant. The sense soon becomes keenly upon the alert, and operative measures prolonged into this period give rise to the most intense pain. Patients will declare the pain in such cases transcends that where no gas is given.

Dr. Halliburton, Assistant Professor of Physiology in University College, was good enough to examine some blood for Dr. Buxton, and he concurs in the results given above. These confirm our own experiments and observations.

Dr. Buxton was anxious to undertake experiments to ascertain whether or not nitrous oxide *produced physical changes in the conditions of the brain*, which were made, by the kindness of Professor Victor Horsley, at the Brown Institution, London.

The skull of a medium-sized dog was trephined and nitrous oxide gas given through a tracheal tube fitted with a very freely-acting expiration valve. The trephine hole exposed the outer third of the sigmoid gyrus on the right side. Under normal conditions the brain was seen some measurable distance beneath the bone, pulsating quietly and synchronously with the respira-

tion. The color of the brain covered with pia mater was pinky-red, or, more exactly, vermilion.

As soon as the animal began to breathe nitrous oxide, the respiratory rhythm being interfered with, the brain pulsations became more notable and somewhat hurried. When the gas was pushed, and the animal made to take it freely, the brain substance was seen to swell up and gradually reach the trephine hole. The color now began to change, and a dark, blue-red shade appeared to creep over the exposed brain, robbing the brightness of the vermilion and replacing it by a laky purple. The brain undulations were at this stage found to lessen in frequency and amplitude. The brain substance still increased in volume, and even protruded without the trephine hole, almost motionless, and of a pearly, glistening lustre of bluish hue. The vessels, examined with a strong lens, presented the well-known look of commencing stasis. At this stage the nitrous oxide was stopped, and the animal allowed to inspire air freely. Quietly and gradually with each successive breath of air the brain receded, the undulations returning and resuming their normal rhythm and range. With these changes came a return of the vermilion tinge which characterizes the healthy brain substance. This experiment was repeated; in some cases the animal was anæsthetized by means of a face-piece with an expiration valve, and in others a tracheal tube was introduced; but the phenomena observed was strikingly uniform. It was next determined to conduct a control experiment, first pushing *the nitrous oxide to the verge of death, and subsequently producing asphyxia by deprivation of all air.* The gas was pushed until respiratory movement completely ceased. In a little over a minute (1 min. 10 sec.) the brain substance had become livid and swollen to above the calvarial edge. The animal was absolutely insensible to painful sensation; his limbs showed marked jactitations. In about 1 minute 30 seconds normal respiratory movements had ceased. *Artificial respiration was promptly resorted to*, and speedily the natural thoracic movements were resumed. The trachea was then occluded and the brain observed. In about a minute the brain substance assumed a deep purple, dull hue, which in another half-minute became very intense;

the brain then began to recede, sinking deeply from the trephine hole. In two minutes the sphincters became relaxed, and further sinking of the brain took place. In three minutes the respiratory movements were very profoundly interfered with, only manifesting themselves by long-drawn gasps, which were separated by long intervals. In five minutes, although all respiratory movements had ceased, the heart still beat. In six minutes access of air was allowed, but artificial respiration failed to effect recovery.

These experiments appear peculiarly instructive, firstly, as showing in a very marked way the difference between the brain condition when fed with nitrous oxide-laden blood, and when supplied with deoxidized blood containing tissue refuse; and secondly, when viewed in relation with the clinical phenomena of nitrous oxide narcosis. As Dr. Buxton has pointed out, there is a zone of hyperæsthesia which separates the normal consciousness from the absolute loss of sensation on the one hand, and on the other which unites the stage of oblivion or sleep with the return to full mental activity. It is presumably at this epoch that the dreams of mental exaltation and physical joy occur, and it is then that slight external physical stimuli—*e.g.*, a flash of light, a noise, a movement—will become a thousandfold magnified and perverted in the patient's brain. The peculiar filling of the brain would seem to offer a physical counterpart for these mental conditions, and apparently so rapidly modifies the brain cells that they are incapable of further reception or ideation; an initial increased exaltation gives way to a complete abeyance of function.

Experiments in the same lines were also made with regard to the action of nitrous oxide upon the spinal cord.* The animal being under the influence of chloroform and curare, the laminæ of the lower dorsal and lumbar vertebræ were removed and the cord exposed lying in the spinal canal. The animal was then

* These experiments were made at the University College Physiological Laboratory, and Dr. Buxton was indebted to Mr. John Rose Bradford, B.Sc., for their execution, and to Professor Schäfer for the use of the laboratory.

made to respire nitrous oxide, only expiring through a slit in the canula. A very marked effect soon showed itself; the cord gradually enlarged and cerebro-spinal fluid began to well out, showing the enlargement of the whole length of the cord. This experiment was repeated, and the same result was always obtained. However, as will readily occur to you, two causes might have conceivably produced this effect, namely, (1) the exclusion of oxygen, *i.e.*, the asphyxia, or (2) the presence of nitrous oxide. To test which of these possible factors was really responsible for the swelling of the cord, the animal was deprived of air, and no nitrous oxide given. At first the cord remained unchanged—at least no swelling took place, and no escape of cerebral-spinal fluid occurred. Soon, however. as the blood became more and more deoxygenized, the cord grew smaller, shrinking below its former level in the spinal canal. There was no doubt but while in nitrous oxide administration the cord, like the brain, grew larger, in asphyxia it shrank. To test this effect further, the following crucial experiment was tried. The animal was subjected to asphyxia, and the cord was watched until it had perceptibly shrunk, when nitrous oxide was allowed to enter the lungs. If. as we assumed, nitrous oxide was capable of dilating the vessels of the cord when acting upon them in a normal condition, it was thought that it should produce a like effect when the cord vessels were contracted by asphyxia. The experiment confirmed this supposition, for as soon as the animal had its lungs well saturated with nitrous oxide, the cord was seen to expand and the cerebro-spinal fluid began to escape.

Conclusions of Experiments upon the Brain and Spinal Cord with Nitrous Oxide Gas.

In brain and cord alike we meet with dilatation of the vessels, with, of course, an increased blood supply to the nerve-centres. Such a condition would be favorable to the dissociation of nervous energy, but this would soon be followed by over-distension and interference with due regularity of the cerebral and cerebellar circulation subversive of ideation and the performance of adjusted muscular action. The interference to the cord circulation must also interfere with the due conduction along its path

as well as with the correlation between its parts and the higher brain centres. At present we may not be in a position to theorize beyond the broad general statements given above, but Dr. Buxton thinks we may justly recognize in the interference with the circulation of the brain and spinal cord, produced by the inhalation of nitrous oxide, a phenomenon which accounts for not only the every-day experience we meet with in giving the gas to human beings, but also to those abnormal cases which occur more rarely and evince marked nervous exhaustion or irregular outbursts of nervous energy. But of these facts we will speak again.

The development of nervous symptoms certainly varies largely with the initial state of the nervous protoplasm, for while in some persons nitrous oxide produces marked nerve disturbance, in others it brings about none whatever.

The Reflexes under Nitrous Oxide.

Among reflexes it is usual to consider two classes, skin or superficial reflexes, of which a familiar example is found in the conjunctival reflex, and deep, of which we have examples in ankle clonus and the patellar jerk and front tap reaction. In health, and under normal functional conditions, the superficial and the patellar reflexes are present; certain pathological conditions lessen or exaggerate these reflexes and cause the development of ankle clonus. The presence of ankle clonus points always to disease or functional derangement of the spinal cord. Now, nitrous oxide produces very marked derangement of the reflexes. In October, 1883, Professor Horsley* drew attention to the persistence of the patellar phenomena under profound anæsthesia, and long after the disappearance of the superficial reflexes. Clonus has been found to be developed in a number of cases, although it is not a constant phenomenon of nitrous oxide narcosis; hence this gas not only abrogates the function of the brain centres, but also produces marked disturbance in the cord, while it blunts or obliterates peripheral sense.

What the exact nature of this derangement of the cord func-

* Brain, vol. vi., p. 369 *et seq.*

tion is we cannot venture at present to offer an opinion; we can only study it by means of the phenomena it reveals. These also are various, differing, it would appear, according to the stability of the nervous centres of the individual subjected to observation. Nor is this surprising when we remember that the effects are very transitory, and must be largely influenced by collateral circumstances. The more constant cord phenomena are—rigidity of the muscles, which passes into complete flaccidity; jactitations, which appear rythmic and general; loss of superficial reflexes; persistence of knee jerk. Among the occasional phenomena we may reckon—ankle clonus; opisthotonus and emprosthotonus; paralysis of the bladder and defæcation centres, and involuntary and unconscious passage of urine and fæces; probably, excitation of the sexual centres, and abolition of the normal checks imposed upon the production of orgasm. Further, we must reckon the secondary results apparently due to a more lasting cord effect, as seen in paresis or even paraplegia following nitrous oxide inhalation. Many of these phenomena are confessedly rare, and are perhaps only elicited in nervous systems predisposed to take on the condition, whatever it may be, which nitrous oxide induces. In some respects nitrous oxide would appear to hold comparison with strychnine. The rigidity, with the occasional liberation of irregular and disorderly explosions of nerve energy, occur, although with different degrees of persistence, alike with one and the other drug. This would perhaps give a clue, and suggest that under nitrous oxide the higher ideomotor centres lose control, the resistances throughout the cord are lessened, and the cells, deprived of the normal restraints imposed by habitual and associated action, tend to irregular explosive outbursts. It seems at least probable that under nitrous oxide not only do we meet with a stage of preliminary exaltation of function, misdirected indeed, and unconstrained by judgment, in the brain centres, exemplified by the stage of hyperæsthesia spoken of above, but that in the lower cord centres we recognize a similar initial heightening of activity, also irregular and disorderly, followed by cessation of their functions. Indeed, Dr. Buxton ventures to think the same sequence of

events happens in the vital centres, and that this explains much of what follows in the remarks made upon blood pressure, cardiac, and respiratory rhythm. But although we may not as yet go far enough to dogmatize upon what is the nature of this action upon the cerebro-spinal axis, yet it seems consonant with our facts to regard it as sedative, which, while provoking an initial exaltation of function, eventually plunges the tissues into a sleep, or state like the long dose of hibernation. Certain it is, in some cases one meets with a quiet prolongation of nitrous oxide narcosis, unaccompanied by the wild convulsions of asphyxia, when the breathing absolutely stops while the heart still beats on. In this state presumably the cord centres have gradually yielded, and, the medulla reached, the respiratory centre has also peacefully ceased from work, and the patient is entranced alike in his mental and vegetative functions. In these cases artificial respiration, conducted for one or two admissions of air, restores the patient to animation, and all goes well. *No danger is, in fact, incurred, unless the anæsthetist is either incompetent or negligent of his solemn charge.* It seems hardly worth while to do more than to beg you *to compare mentally these* phenomena with those afforded when asphyxia terminates life. To contrast what has just been described with *the mental activity persisting almost to the last gasp, the purposeless struggles, the wild, chaotic respiratory efforts, the frantic writhings of the voluntary muscles, and at length the general massive convulsions passing into a false quiet, marked by an occasional gathering together of the failing nervous energy to effect a spasmodic explosion of muscular force.*

THE INDUCTION OF ANÆSTHESIA IN HEART FAILURE.—It is a matter of very great importance for us to determine the behavior of nitrous oxide towards the heart and vascular system in general. Dr. Buxton's and our own investigations in this direction have been made to ascertain the action of the heart, and the variations of blood pressure under nitrous oxide; and further, to determine how far the variations seen when nitrous oxide was exhibited were due to that body, and how far to the coincident deprivation of oxygen.

The animals selected were dogs and cats, but as the results

were practically uniform, it is unnecessary to particularize the experiments. Dr. Buxton dwells on his great indebtedness to his friends, Professor Victor Horsley, Mr. Bradford, and Professor Schafer, through whose kindness alone the research was practicable.

The heart's action under nitrous oxide does not become much affected, and even in cases in which that gas is pushed until complete cessation of respiratory movements occur, the heart still continues to beat, its action gradually growing weaker. In no case have we seen any tumultuous action of the heart or a sudden cessation, only the gradual sinking to rest noticed above. The attempt at narcotizing animals and timid persons produces a temporary acceleration of heart beat, but as soon as the intellect becomes under the influence of the narcotic this acceleration passes off, and the heart beats become regular, strong and somewhat slowed. It will be remembered that these results are in accord with the statements already published, and based upon numerous sphygmographic tracings taken of the human radial pulse.

The blood pressure under nitrous oxide inhalation has the following peculiarities: For the first period it shows little change, but subsequently a fall of pressure takes place. Upon allowing the animal to inhale air, the blood pressure recovered itself, but only gradually, and by passing through a phase of somewhat irregular curves. These curves are not respiratory, as they take place even when the animal is completely paralyzed with curare, and artificial respiration is maintained. In some cases a slight, but very slight, rise in the blood pressure took place, but a rise of blood pressure which persists for a notable time appears always to follow the nitrous oxide inhalation. Control experiments were conducted to test the effect upon blood pressure when the animal is deprived of air. These were done upon curarized animals in order to avoid the interference caused by dyspnœic convulsions. As soon as the air supply was cut off, the blood pressure began to go up, and rapidly increased until the heart's action, which lessened in force *pari passu* with the heightened blood pressure, became so weak that it was necessary to allow air to enter the lungs. The blood

pressure then resumed its normal height very quickly, but the rise which follows after nitrous oxide administration does not appear to ensue after asphyxia.

Reviewing Nitrous Oxide Experiments.

Dr. Buxton and the author, upon *reviewing the nitrous oxide experiments*, and controlling them by the asphyxia experiments, prove nitrous oxide itself has no very marked influence upon the heart or vessels; what action it has is to steady and slow the heart, and, if anything, to strengthen it, and the action is somewhat prolonged. The vessels, at first almost unaffected, later undergo a peripheral dilatation leading to a lowering of blood pressure. This, however, is true only when reservation is made; for, as we shall see, the splanchnic vascular areas are contracted at first. Upon this last statement I have some additional evidence to offer. A good-sized frog (Rana temporaria) that was placed beneath a dome-shaped glass vessel, was so arranged that the web of one foot was outside the vessel, and could be examined under the microscope. The dome was emptied of air and kept full of nitrous oxide, and the frog carefully noted while the web was examined. It was necessary to keep the whole animal in nitrous oxide, as cutaneous respiration is very active in the frog. At first the circulation in the web was found to be slowed; at the same time the minute vessels were seen to dilate, and this slowing and dilatation both became more marked as time went on. Changes also appeared to develop in the corpuscles, by which they took on a flattened, compressed appearance. At length the respirations, which had become slower and slower, became almost extinguished, the capillary circulation in some areas was almost in a condition of stasis, whilst throughout the field extreme slowing had occurred. At this point the frog was allowed free access to air, and at once the respiration quickened, the blood-flow increased in rapidity, becoming many times more rapid than under the gas. The corpuscles resumed their normal aspect. The results of such experiments upon the frog point to a peripheral dilatation of capillaries, and of this further evidence has yet to be adduced. It needs no argument to show that a vascular viscus, like either

the kidney or the spleen, must, under variations of blood supply, undergo variations in size. If, therefore, it were possible to inclose either viscus in an air-tight receiver communicating with an oil manometer, it would give indications of increase or diminution of size according as the blood supply were increased or lessened. Mr. Bradford has kindly enabled us to investigate this point pretty fully.

Experiments with Nitrous Oxide on the Kidney.

The experiments made upon the kidneys were tolerably numerous, and were singularly uniform in their results. The kidney in an animal *narcotized with nitrous oxide speedily undergoes contraction, which corresponds of course with the contraction of the renal arteries.* This contraction continues as long as the nitrous oxide is given, but as soon as that is cut off and the animal respires air the kidney speedily recovers its normal size, but no dilatation of vessels beyond normal takes place. With this condition we have to compare the behavior of the *kidney in an animal subjected to asphyxia.* Here the *kidney undergoes a dilatation as soon as the air is cut off.* This corresponds with dilatation of the renal arteries, and is probably due to increased heart action called into being by the venosity of the blood. Later, when the heart fails, the kidney suddenly contracts, a very rapid fall in the kidney curve occurring. Thus a singularly striking contrast in the behavior of the kidney reveals itself, according as that viscus is influenced by nitrous oxide or asphyxia. This effect upon the renal circulation must not be taken as militating against the statements made above with regard to the general blood pressure as shown by the carotid artery and about the circulation in the brain and cord. It is well known that certain sedatives—morphine, for example—dilate the vessels in one area while they contract those of other areas.

The effects produced by nitrous oxide upon respiratory rhythm.

The chest movement will, as is well known, continue without any air entering if a sufficiently long and small elastic tube be attached to the tracheal canula, so that one can easily compare

asphyxia with nitrous oxide narcosis. In the last condition the respirations are at first quickened, but not lessened in depth; later they grow slower and deeper, and still later they become very slow and somewhat more shallow; finally they cease. The time in which this cessation comes about varies considerably in animals. *I have not seen the dyspnœic struggles under nitrous oxide which asphyxia brings about.*

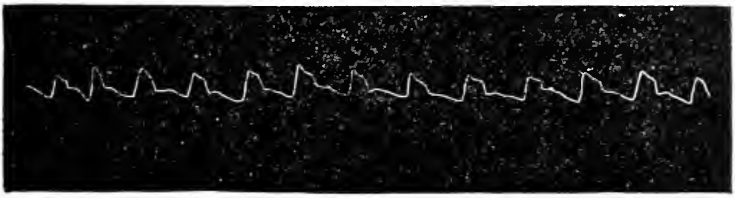
Sphygmographic Tracings from Patients under the Influence of Nitrous Oxide Gas. (After Mowat.)

In about half to three-quarters of a minute the patient's consciousness is lost, and soon after the pupils will dilate, the eyes becoming dull, with loss of expression, and there may be strabismus. This is the primary condition of anæsthesia, when if the conjunctiva is touched, the reflex is still there, and yet at this stage, a single tooth, or a very slight operation can be performed. If, however, the inhalation is continued for a minute longer, the breathing becomes stertorous, muscular movements of the hands and feet take place, and the conjunctiva can be touched without any movement. Should the breathing stop for more than ten seconds air must be given. This is the period of deep anæsthesia, and should the heart intermit, and pulse at the wrist not be felt, air must be introduced and the gas stopped. If everything remains in good condition, now is the time for operation.

It is well known that as soon as the inhaler is placed over the mouth and nose of the patient he begins to respire more quickly and his pulse increases in speed. This, however, is due to excitement resulting from the fear which usually accompanies the inhalation. As soon as inhalation begins respiration becomes slow, the tension of the pulse falls, the number of beats per minute is increased, the tidal or predicrotic wave is slightly better marked, and the dicrotic wave becomes so well marked as to constitute that pulse which is known as fully dicrotic; sometimes, indeed, it is even slightly hyperdicrotic. As anæsthesia proceeds the tension of the pulse falls considerably, whilst the number of pulsations increases. The tidal and dicrotic waves still remain very well marked. When the

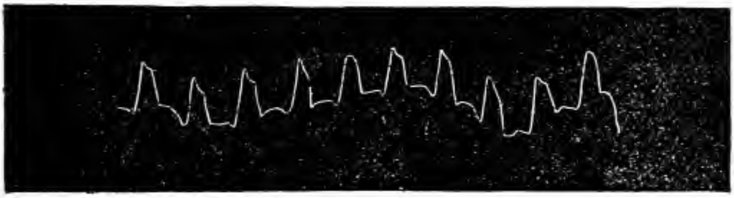
mouth-piece is removed and any operation is to be performed, the pulse undergoes a marked change. This is probably due to a reflex action through the vagus to the heart. Immediately after the operation the pulse gradually assumes its normal con-

PLATE 18. (Figs. 1–3.)



1

Normal pulse.



2

Fully under nitrous oxide with lowering of arterial tension.

3

Tidal wave appearing.

dition, passing (in the reverse order) through the stages it had undergone when the nitrous oxide gas was applied.

As a matter of course, every patient is a law unto himself as regards the time required to come fully under the influence of the anæsthetic, and even the same individual will differ at different conditions of the system.

The Committee appointed by the Odontological Society of

Great Britain found the following averages in a large number of administrations of the gas:

	Time going off.	Duration.	Time from commencement to recovery.
Males, ...	1 min. 21 sec.	24 sec.	1 min. 55 sec.
Females, ...	1 " 16 "	28 "	2 "
Children (under 15),	1 " 3 "	22 "	1 " 49 "

In human beings I have seen, especially in children, complete cessation of respiration without the slightest preliminary struggle. Alike in the lower animals and man, the breathing recommences if pressure is made on the chest. These changes in respiration are, I am inclined to think, due wholly to the action of nitrous oxide upon the nerve centres presiding over respiration.

On Blood Alterations by Anæsthetic Agents—Conclusions.

In conclusion, there are various practical considerations which the writer thinks may well be taken into review while studying the physiology of nitrous oxide narcosis.

If nitrous oxide acts as a sedative in virtue of its own inherent properties, and does not owe its value as an anæsthetic to asphyxial processes called into play by concurrent privation of oxygen, it should be our aim to *push the gas and give free vent to expired gas.* We should see that our patient changes as freely as possible his residual air during inspiration, and expires as freely as possible the refuse-laden nitrous oxide, which has been stationary within the air-spaces during the last respiration. We cannot but think that, whatever may be the *saving* of gas brought about by *employing supplemental* bags wherein the nitrous oxide is *collected* and *reinspired again* and *again*, the patient suffers thereby from the double evil of *breathing diluted and impure nitrous oxide*, and, further, is not favorably placed

for exhaling the refuse of the lungs. We should incline to attribute to this method the *cases* one occasionally meets with of *severe headache, vertigo, dizziness* and other untoward symptoms consecutive upon nitrous oxide inhalation. It is a very important point to induce very free inspirations of *pure* nitrous oxide, and to avoid anything like inducing partial asphyxia, and in practice this gives the best and most satisfactory results.

The behavior of the heart under nitrous oxide should encourage us to use this agent freely, and during its administration to *watch rather* the *respiration* than the pulse, since it would appear that *syncope*, if it occur, occurs secondarily through the *lulling* to *sleep* of the *respiratory centres*. The cases in which nitrous oxide has been said to kill by heart failure are few, and even in these we are not at all sure that the fatal faint was not due to fear or shock incurred by a nervous system already shaken by suffering, and rendered still more obnoxious to shock by an imperfect narcosis. When we remember the period of heightened sensibility which precedes complete restitution of consciousness, we can easily comprehend the terrible jars a debilitated nervous system must sustain if operative procedure be carried on into this stage. Clover long ago pointed out from his vast clinical experience that patients may be allowed to cease breathing, and yet no fear need be entertained, as a few vigorous pressures upon the thoracic parietes will reinitiate respirations. Now we accept his statement, and explain it under physiological laws.

There are other practical points that are suggested by knowledge of the action of nitrous oxide. Of these, not the least important is that the erotism called into existence in a fairly large proportion of patients, and controlled only in a few by the restraints of habitual thought and judgment, should render all persons most careful to avoid possible incrimination through hallucination. For the sake alike of patient and operator, a witness should always be within earshot, or within sight, whenever nitrous oxide is administered.

Again, the decided action this anæsthetic has upon the nerve centres, and its tendency to call forth irregular explosions of

nervous energy, might by some be taken as contra-indicatory to its employment for patients who are the subjects of epileptiform seizures. We do not, however, think we can with justice say that the giving the gas renders a fit more likely to occur than the operation. We are aware any strong excitant will call forth a seizure, whereas the sedative action of the nitrous oxide will, by lessening stimulation from without, be less inclined to provoke the attack.

Nitrous Oxide in General Surgery.

Dr. L. Macdonald, of Washington, D. C., has found, while not discarding ether and chloroform, nitrous oxide gas capable of producing anæsthesia of a degree that was quite satisfactory for the performance of such prolonged operations as breast extirpation, laparotomies, hysterectomies, amputations—indeed, almost all operations in surgery, except those within the oral respiratory tract, whether the operation required, two minutes or two hours,

It cannot always be relied upon to produce thorough and complete muscular relaxation. It is therefore not the best anæsthesia for use in the examination of joints, displacements, fractures, etc. From the point of economy and convenience he has found it is far inferior to other anæsthetics, as each protracted operation costs about two dollars.

We have published in our third edition, p. 136, that as early as March, 1874, Dr. D. H. Goodwillie published a paper, which had been read before the Medical Library and Journal Association of New York, of his success in a prolonged surgical operation by the administration of nitrous oxide gas.* On April 20, 1875, C. A. Brackett, D.M.D., of Newport, administered the gas (about thirty minutes) for Dr. Squire of that city for the removal of a cancer of the breast (second operation), as he did not dare to give ether, the patient being so debilitated.†

It is Dr. Brackett's impression that the late Dr. J. Marion Sims was among the earlier, if he was not the earliest, to use

* Johnson's Dental Miscellany in March, 1874.

† Private letters of Dr. Brackett.

nitrous oxide in long operations, and notably in uterine and abdominal surgery. His knowledge of anæsthetic agents was comprehensive and intimate, and the nature of the operation which he specially performed gave him strong reasons for wishing to avoid the vomiting and retching following the use of ether. There probably are records accessible to determine, at least approximately, the time of his beginning to use nitrous oxide in his practice. However, in the article above named, page 224, Dr. Sims says:

"Nitrous oxide has been used in general surgery by many eminent surgeons in New York, Philadelphia, Baltimore, and elsewhere. It has been used successfully in New York by James R. Wood, Carnochan, and others. The late Marion Sims has used it in difficult and prolonged operations (ovariotomy) requiring thirty, forty, fifty-seven and sixty minutes, and in one case one hour and fifty minutes, and always with most satisfactory results."

The reference on page 136 to Dr. Goodwillie's article should be to "Johnson's Dental Miscellany, Vol. I., No. 3, p. 85."

"Dr. Brackett appreciated many years ago the fact, that owing to the necessity of suspension of administration before operations in the mouth began, nitrous oxide was, in a sense, less well adapted to such operations than it is to almost all other minor surgery. Some years ago he was permitted to address the Newport Medical Society on the subject at a regular meeting, urging then, as he had done many times privately before and since, the great aid and comfort that nitrous oxide may and should be to general practitioners and specialists, other than dentists, in multitudes of cases occurring every day in which such help would be acceptable. It is most gratifying to him that the agent is gradually winning its way to a larger usefulness."

Nitrous Oxide and Oxygen as an Anæsthetic.

The great advantages of nitrous oxide, as an anæsthetic, have induced various observers to endeavor to find a method of administering gas continuously, so as to keep up the anæsthetic

influence for a sufficient length of time for the performance of surgical operations.

Paul Bert, some years ago, made experiments with animals in a chamber of compressed air, a mixture of nitrous oxide and oxygen being inhaled. He found that anæsthesia could be kept up for a long period, and he urged the construction of such chambers for operating upon the human subject. Some few experiments were made in minor surgery, but nothing was attempted on a large scale on account of the bulk and expense, etc.

In 1881, Dr. Si Klikovich, in St. Petersburg, made some experiments on himself with a mixture of nitrous oxide and oxygen in the proportion of 80 to 20, without any increase of atmospheric pressure, with a satisfactory result. Zweifel soon followed, and later Hillischer.

Hewitt's Apparatus.

In 1892 I received from my friend, Frederick Hewitt, M.D., of London, Lecturer on Anæsthetics at the London Hospital, a pamphlet in which he gives the report of a series of cases, with a description of his apparatus and mode of using the same. I have had also the opportunity of testing his instrument, as examiner of anæsthetics, in conjunction with Professors Dorr and Cryer, at the Philadelphia Dental College.

The following is an illustration of the instrument, with a description :

Hewitt's New Simplified Portable Apparatus for Administering Nitrous Oxide and Oxygen.*

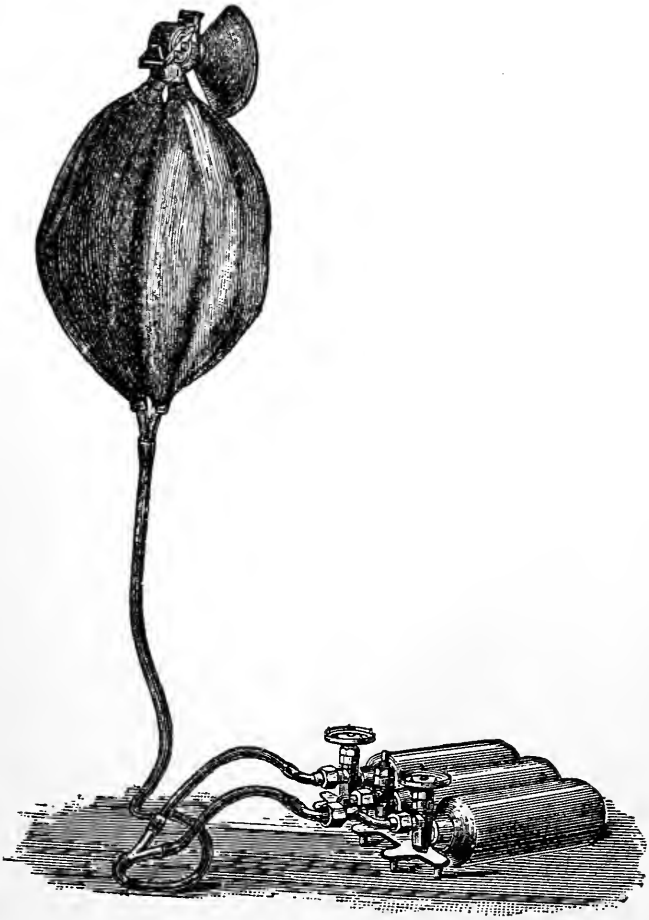
Directions for Use.—All air or gas should first be pressed out of the double bag,† the indicator turned to "air" (see

*See Dr. Hewitt's paper on "Further Observations on the Use of Oxygen with Nitrous Oxide," in *The Journal of the British Dental Association* for June 15th, 1894.

†It is not advisable to press the bags too tightly, as the suction caused by the sides adhering together has a tendency to draw the valves in the delivery tubes through to the wrong side.

Plate 20), and the two divisions of the bag nearly, but not quite, filled with their respective gases, by rotating the foot keys. No further addition of oxygen will be needed. The

PLATE 19.



Apparatus complete.

face-piece should then be very accurately applied. Air will be breathed freely through the apparatus. The valves should be heard to act, otherwise the face-piece is not fitting, or the patient is not breathing as freely as he should. The indicator

is now turned to "1," which means that nitrous oxide with a small quantity, possibly 1 or 2 per cent., of oxygen will be inhaled. It is most important that the two divisions of the double bag should be kept *equally and partly distended*, as shown in Plate 19. The anæsthetist must therefore keep his foot almost constantly turning the nitrous oxide foot key in order that the two parts of the bag may remain equal in size throughout. After two or three breaths at "1" the indicator should be turned to "2," and progressively, after every two or three breaths, to "3," "4," "5," "6," "7," "8," "9," or "10," according to the type of patient. In children and very anæmic persons the indicator may be placed at "2," "3," or even "4," to start with, and turned to a fresh number every breath or two. But in adults in good health less oxygen must be given.

IMPORTANT.—As it is essential to the proper working of the apparatus that all the four valves act well, and the ten oxygen inlets be kept entirely clear, it is recommended that the apparatus be taken apart from time to time and the condition of these ascertained.

TO EXAMINE OXYGEN INLETS.—Take out the three milled head screws, remove the indicator handle with detent spring, replace the centre screw in dial side of stop-cock, and pull out the inner drum. If any of the openings appear to be clogged pass a piece of metal wire of suitable size through each one until quite clear.

LUBRICATING INNER DRUM.—It is very important that no grease or oil be put on that part of the drum which revolves immediately over the oxygen inlets. Any neglect of this will cause them to get choked, and render it necessary to take the apparatus to pieces again.

TO EXAMINE VALVES IN DELIVERY TUBES.—Slip off the necks of gas bag one after the other, the valves can then be drawn out of the tubes by the finger. In replacing them always have the inlets to mixing chamber open, to avoid the rubber dies being forced through to the wrong side.

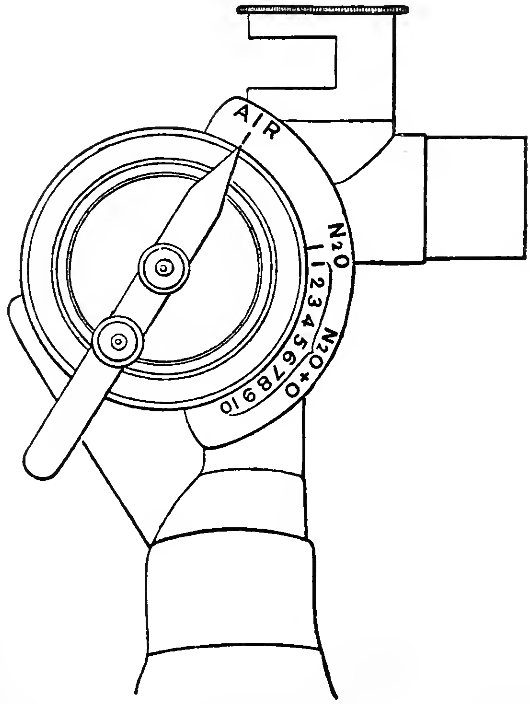
The centre screw, which keeps in position and regulates the tension of the detent spring, will in time get somewhat slack;

it should then be screwed up again to the necessary degree of tightness.

The experience of many observers, but especially that of Professor Hillischer, of Vienna, and Dr. Hewitt, of London, demonstrates the fact that a mixture of oxygen with nitrous ~~acid~~ may be practically utilized as an anæsthetic, and that such

oxid

PLATE 20.



Indicator, etc.

a mixture is in all respects the safest and most satisfactory agent at our command for minor surgical operations. It enables us to utilize the anæsthetic feature of nitrous oxide without its one element of danger, viz, its tendency to produce asphyxia. While the records show that the asphyxial factor of nitrous oxide narcosis is but a slight element of danger in its use—for no anæsthetic has been so largely and indiscriminately used—it is still important that we should take advantage

of any means which will successfully eliminate this one dangerous feature. The method and apparatus devised by Dr. Hewitt fully meet all practical requirements, and though somewhat more complicated than the ordinary nitrous oxide apparatus, is sufficiently simple and convenient, as is seen in the drawing he has sent us.

In our own experiments we have found that it takes a little longer time to induce anæsthesia in the human subject by the mixture of nitrous oxide with oxygen than when pure nitrous oxide is used. There is to be noted in this connection that while it takes longer to induce anæsthesia with the oxygen and nitrous oxide mixture than with nitrous oxide alone, the resulting anæsthesia is of longer duration where the mixed gases are used.

Dr. Hewitt's figures relative to average period for inhalation for dental operations are as follows :

	Average Period of Inhalation for Dental Operation.	Average Period of Resulting Anæsthesia.
N_2O per se, ...	About 51 seconds.	30 seconds.
$N_2O + O$ in sufficient quantity to prevent all asphyxial symptoms, ...	About 110 seconds.	44 seconds.

In typical cases of anæsthesia by mixed oxygen and nitrous oxide, there is almost an entire absence of cyanosis, stertor or jactitation, which are the characteristic symptoms of asphyxia. It is this fact which proves our theory that nitrous oxide possesses anæsthetic properties apart from those which it induces by virtue of its shutting off of oxygen. According to Jolyet and Blanche, coma is not produced until the amount of oxygen in the blood is reduced to between three and four per cent. When so reduced, we have cyanosis as a concomitant.

The absence of duskiness of the features may be relied upon as an indication that there is certainly a greater amount of oxy-

gen than four per cent. present. M. Claude Martin, of Lyons, administered to a dog a mixture of nitrous oxide with fifteen per cent. of oxygen for three consecutive days, with apparently no ill effects upon the animal. "It must be evident, then, that we have to deal, in the case of the mixed gases, with an anæsthetic which does not induce asphyxia; or, if so, the condition is modified to an extent which obliterates its ordinary characteristic symptoms. It is also evident, for this reason, that it possesses greater freedom from danger. If it can be demonstrated that the anæsthesia induced by the mixture of nitrous oxide and oxygen, is nevertheless caused by the action of insufficiently oxygenated blood upon the nerve centres, notwithstanding the entire absence of all of the usual symptoms of oxygen-starvation, we may strongly suspect that other well-known anæsthetics act in an analogous way, by interfering with proper oxygenation of the blood."

On Dr. Hewitt's Method of Using Nitrous Oxide and Oxygen as an Anæsthetic.

The views which have been published in this country have been, in the main, favorable to the employment of Dr. Hewitt's method in dental operations and minor surgery. The following was the time consumed by this method in the case of two patients, Dr. J. D. Thomas performing the operation for the removal of carious teeth. In the first case, one hundred and ten seconds were consumed before the corneal reflexes were fully abolished, and, as nearly as could be determined, there remained forty seconds of available anæsthesia after removal of the face-piece.

In the second case, one hundred and sixty seconds were consumed in the administration, resulting in thirty seconds of available anæsthesia. In the pulse, as reported, at the close of the administration there was found but slight variation either in fulness or frequency. There were none of the usual symptoms of asphyxia manifested, there being an entire absence of blueness, stertor or jactitation. Dr. Thomas objects to the face-piece of Dr. Hewitt, as he desires at all times to see the patient's lips.

Dr. Kirk,* who read a valuable paper on the subject of Dr. Hewitt's method from personal observation, made the following remarks at the conclusion of the discussion:

"I want to correct one idea of Dr. Thomas that is erroneous, namely, that the time of administering the mixed gases is in any sense a guide to the condition. We were simply timing the administration as a matter of record, and not as a guide for the anæsthetic condition produced.

"There is another point to be borne in mind in relation to the face-piece as used in this method. By Dr. Hewitt's method you are giving oxygen in connection with the nitrous oxide almost from the start, and the patient is getting a certain amount of oxygen immediately. There is no time when the patient is not taking some oxygen. Consequently, the chances of oxygen-starvation are very much lessened, the asphyxial condition to which Dr. Thomas alludes being constantly prevented, and we thus eliminate what is a very potent element of danger in giving nitrous oxide alone.

"I quite agree with him as to the danger of proceeding with the administration where the patient so quickly succumbs and becomes cyanotic under pure gas. There the face-piece, I admit, is a serious objection, but in the method of Dr. Hewitt the fact that we are giving oxygen continuously with the nitrous oxide is a safeguard against any accident which may occur from the inability to see the lips."

Conclusions of Dr. Hewitt.

"So far as my experience has gone, I am inclined to regard the use of oxygen with nitrous oxide as of distinct advantage in the large majority of cases in dental practice. But we cannot shut our eyes to the fact that the administration of the mixed gases involves more time, more attention to detail, and more skill than are essential for the employment of nitrous oxide in the ordinary manner, whilst the risks of unpleasant after-effects

* Dental Cosmos, Dec., 1894, *op. cit.* Experiments made with Prof. Dow and Dr. M. H. Cryer. Dr. Kirk, editor of the Dental Cosmos, meeting of Academy of Stomatology.

are a trifle greater. It hence follows, that unless we can show that the gain is considerable we are hardly justified in advocating any departure from the usual lines of practice. I have attempted to point out that *in many instances* this gain is considerable, and for my own part I shall certainly continue to use the mixture in preference to ordinary nitrous oxide for such cases. But when a very short operation has to be performed upon a patient who has taken nitrous oxide itself on a previous occasion with the best results, I would continue to use it."

When any additional preparation might alarm a nervous subject, or when time is a matter of great consideration, the use of nitrous oxide *per se* is possibly preferable to that of the mixture. I need hardly remind you that it is not always an easy matter to prophesy the duration of an operation. A tooth which is looked upon as easy of removal often gives trouble, and under these circumstances an additional fifteen or twenty seconds in the anæsthesia may make all the difference in the result of the case.

By the use of the apparatus brought before your notice, an attempt may be made in every case to secure the satisfactory form of anæsthesia which has been described. Should the case turn out to be an exceptional one, nitrous oxide alone can at once be substituted with the best results. In this way every case may be brought to a successful issue. The extra trouble incurred by having a bag full of oxygen in communication with the ordinary nitrous oxide apparatus is very small, whilst the benefits that will result in the majority of cases from the addition of a proper proportion of this gas are very great.

The mixture is to be chiefly recommended as preferable to nitrous oxide itself—

(1) In children;

(2) In anæmic and debilitated patients;

(3) In any one who has previously exhibited great unsusceptibility to nitrous oxide, and has remained a very short time under the influence of the gas;

(4) In patients who, under nitrous oxide itself, have experienced unpleasant sensations;

(5) In patients very advanced in years, and in those suffering

from such serious visceral disease that ordinary nitrous oxide seems unadvisable.*

Observations on the Statements and Abstracts from Monograph of Dr. H. C. Wood.†

Experimental Study of Nitrous Oxide.

The length of time which Drs. Wood and D. Cerna found to elapse between the commencement of inhalation and anæsthesia, varied from fifty-one seconds to three minutes and fifty seconds. The average period, two minutes and eight seconds. This is the same as given in our manual, p. 92, one minute fifty-five seconds; never less than one minute forty-nine seconds. Pulse experiment, 1. The inhalation of nitrous oxide was immediately followed by an enormous rise of arterial pressure, associated with great disturbance of the pulse; the heart beats very irregular, with long pauses, followed by a number of very rapid pulse beats. Compare these with the tracings at p. 91, on man in our work. This increase of the pulse in man is sometimes due to excitement resulting from fear. As soon as the inhalation is free and full, respiration becomes slow, the tension of the pulse falls, the number of beats per minute is increased, the tidal or predicrotic wave is slightly better marked, and the dicrotic wave becomes well marked. When the mouthpiece is removed, and any operation is to be performed, the pulse undergoes a marked change. This is probably due to reflex action through the vagus to the heart. Immediately after the operation the pulse gradually assumes its normal condition (in the reverse order) through the stages it had undergone when the nitrous oxide gas was applied.

Experiment 4 shows the pulse so characteristic of the action of nitrous oxide gas. When the pneumogastric had been previously divided it is absent, and it is therefore due to stimulation of the inhibitory cardiac apparatus. This is the same idea,

* Pamphlet received from Dr. Hewitt.

† Presented to the International Congress, Berlin, August 6, 1890, with the experiments with Dr. D. Cerna (The Therapeutic Gazette, August, 1890).

only in different language, as is our work. The extraordinary rise in arterial pressure which took place in some of Dr. Wood's experiments during the inhalation of nitrous oxide gas, has, as he observes, an important bearing upon practical medicine.

Some time since a death from apoplexy occurred in Philadelphia* directly after the inhalation of nitrous oxide, and it is well known that Dr. Lafont, of France, has asserted that occasionally diabetes mellitus and albuminuria, have been produced by the anæsthetic use of nitrous oxide. It is entirely conceivable that in a man with atheromatous or otherwise diseased arteries the inhalation of the gas might cause a rise in the arterial pressure, which should produce rupture of smaller or larger vessels, and cause serious symptoms.

Chloroform directly depresses the heart, and even ether has a similar influence when it is in excess, but nitrous oxide would appear directly or indirectly, to stimulate the heart and to keep up this stimulation, at a time when the respiratory function is almost *completely* obliterated.

Experiments with Nitrous Oxide Gas and Nitrogen Gas.

"A lost respiratory function can be temporarily replaced by artificial respiration, but no substitute has been found at all for an arrested heart. It is easy to see why death has so very rarely occurred during anæsthesia from nitrous oxide. Dr. Wood comes to the conclusion by experiment 'that the fall of arterial pressure which occurs in the advanced stage of nitrous oxide anæsthesia, is due to vaso-motor paralysis.' The same danger, according to the Hyderabad Commission, is to be found in chloroform, viz., paralysis of the vaso-motor centre. Nitrogen gas also received the attention of Drs. Wood and Cerna. The experiments were three in number.† In the first, unconsciousness was complete in one minute and ten seconds. Death

* See details of case, Manual of Anæsthetics, p. 115; also influence of Nitrous Oxide on Brain and Spinal Cord, p. 18; and also a recent report of deaths.

† Therap. Gaz., 1890.

occurred three minutes after the beginning of the inhalation of the gas; the arterial pressure was raised in forty seconds twelve millimetres; during the next ten seconds it went up ten millimetres more, and then fell abruptly eighty to ninety millimetres in the next ten seconds, and continued to fall until death took place. The other two were similar, as may be seen by the table. The experiments, according to the doctor, indicate a parity of action between nitrogen and nitrous oxide, that the two agents act in a similar manner, that is, by shutting off oxygen."

Oxygen and Carbonic Acid.

"In the second series of these experiments was determined the action of oxygen and carbonic acid. In the first of these experiments, after the inhalation of pure oxygen for two minutes, the pulse was four beats per minute below its starting-point, and the arterial pressure three millimetres below its level. Experiment 13, the pulse at the end of four minutes of inhalation had been reduced eight beats, while the blood pressure had fallen four millimetres; in the third experiment about the same.

"These experiments certainly show that the inhalation of pure oxygen gas has no influence upon the circulation—a simple pumping out of the blood of carbonic acid. Then followed a direct experimental study of the effects of carbonic acid, pure and dilute with air, upon arterial pressure.

"As a result of the experiments, Dr. Wood thinks that the following proposition is established: carbonic acid, when breathed into the lungs alone, sometimes causes a slight and temporary rise in the arterial pressure, but usually after a short time a very decided fall, having the most power when mixed with oxygen in the proportion of two to one. It also acts as a powerful pulse depressor. After section of the vagi, the inhalation of carbonic acid does not produce slowing of the pulse."

The observations and experiments on oxygen of Dr. Wood differ from our own and many others, as we will be able to show under oxygen.

The After-Effects of Nitrous Oxide Gas.

Many persons will remember that both Dr. Barker and the late Dr. Webb, while living, declared that they felt some ill effects in their own persons from nitrous oxide gas.

No one can read the full account which we have given of the physiological action of this gas upon the nervous system, more especially the brain and spinal cord, without perceiving the powerful impressions which it makes upon these important organs, and how near unto death it may bring the patient. In our own experiments and those of Dr. Buxton on the brain and spinal cord, we have met with dilatation and laceration of the vessels, with of course an increased impulse in the blood supply to the nerve centres and vessels.

Such a state would indicate a condition favorable to nervous energy, but this is soon followed by interference with the due regularity of the cerebral and cerebellum circulation, if carried too far, producing irregular muscular action, rigidity and nervous exhaustion; also disturbance producing marked reflex action and even ankle clonus. Amongst the occasional phenomena which occur are opisthotonus, paralysis of the bladder and involuntary action of the urinary and rectal secretions.

Another distressing class of symptoms are the excitation of the sexual centres and abolition of the normal checks imposed upon the production of orgasm.

In some cases there is a quiet prolongation of nitrous oxide narcosis, unaccompanied by the wild convulsions of asphyxia, when the breathing absolutely stops while the heart beats on.

Fortunately, in these cases, artificial respiration, conducted for one or two admissions of air, restores the patient to animation, and all goes well.

No danger is, in fact incurred, unless the anæsthetist is incompetent or negligent of his solemn charge.

The following observations expressed in a recent discussion on the subject are of value:

"Dr. J. D. Thomas recognized ten or twelve years ago the dangerous element of asphyxia in giving nitrous oxide, and it came in this way. In operations requiring considerable time it was considered dangerous to continue the inhalation long, but

by alternating a breath of air with a breath of gas it seemed to overcome all dangerous symptoms which accompany the asphyxiated condition from the use of pure nitrous oxide. Even in that class of persons who asphyxiate very easily, showing oxygen-starvation which begins as soon as the first or second breath is taken, the admission of a little atmospheric oxygen will relieve it, so that has been the method which I have followed for ten or twelve years in certain cases, but not in all.

"In giving nitrous oxide, the only danger accompanying it, in my mind, is the want of oxygen. That is exhibited in numerous ways. All the deaths that have occurred, when not by accident, and which have resulted from the physiological action of nitrous oxide, have been, to my mind, from the want of oxygen.

"As to accidents, many things might occur. Among others, the one where there is considerable jactitation producing constriction of the glottis. This is the result of asphyxiation, and one breath of air will relieve it entirely. Yet the glottis may be so constricted as to produce actual suffocation; one or two have died in that way. That is, in my judgment, an accident, for as soon as the patient gets a breath of air he is safe. If the trachea had been opened below the larynx it would have been obviated.

"Another phase of the want of oxygen is that shown in the respiration of people who breathe very slowly and who never oxygenate the blood to the proper degree in normal respiration, and who thus never get a full supply of oxygen. The moment it is reduced or cut off they immediately show an asphyxiated condition, and sometimes very quickly a suspension of breathing, which is perhaps the first exhibition of danger. Most of the deaths have been shown to have been by suspended respiration, the heart's action continuing some time afterward, sometimes ten or eleven minutes.

"Now there is the other extreme, the class of anæmic people; their blood is lacking in red corpuscles to such an extent that the lips show no color at all. I have seen cases of this anæmic character which will often succumb, after taking the second breath of nitrous oxide, before any effect could possibly have

been made on the nerve centres directly by the gas. It is not the effect of the anæsthetic, but simply want of oxygen, a starvation of the nerves that control the action of the heart.

"These are two conditions which, to my mind, are dangerous ones in giving nitrous oxide.

"With the extremely anæmic, by the admission of air we can obviate the asphyxial condition, so that they can be carried to a state of unconsciousness without any of those symptoms occurring. Again, the extremely florid show the effects of asphyxia very readily, simply because they demand all the oxygen that the lungs will supply to aerate their blood sufficiently; when you cut off any of it, the blue appearance will take place almost immediately, with the second or third breath. If you continue, without the admission of oxygen, they will discolor and be affected to such an extent as to go into convulsions, not only jactitation, but absolute convulsions. I have seen that take place."

The inhalation of nitrous oxide gas, long continued, causes progressive depression of the vital functions, which, like all systematic anæsthetics, tends to death. This must never be forgotten.

Accidents in Extracting Teeth under Nitrous Oxide.

Dr. Buxton gives some important hints in extracting teeth while under the influence of nitrous oxide gas. "The mouth should be cleared of artificial dentures, especially small plates. Accidents have arisen from teeth, or portions of teeth, being allowed to fall from the beaks of forceps back over the glottis, a deep inspiration then drawing the tooth into the trachea. The tooth forceps have, in recorded cases, broken and a fragment become lodged in the trachea. All instruments used for the mouth should be carefully examined for flaws, and all gags, props, etc., should be secured by fishing gut or some strong, cleanly material and attached outside the mouth.

"In extracting teeth, the forceps after each extraction should be wiped *twice*, as taught by Clover, before attacking another tooth. Fragments of teeth should never be left in the mouth,

even with the object of gaining time; each fragment should be removed before any further proceedings by bending the head forward and sweeping the finger around the mouth. The tongue must not be drawn forward, as by so doing the larynx will be left exposed, the epiglottis being dragged from it, while the patient is thereby induced to take a deep inspiration, which will probably cause the foreign body to enter the air passage.''

In its pure state the gas may be given to almost any one, if judiciously administered.

Among the difficulties which may be met with as having the appearance of danger in administering nitrous oxide, the most common is constriction or spasm of the glottis, or swallowing the tongue. The use of the prop cannot be over-estimated in such cases. The patient becomes very dark in the face; there is a violent exertion of the diaphragm, and he presents every indication of approaching asphyxia, which, by having the mouth well propped open, is very readily relieved by catching hold of the tongue with a dry napkin and pulling it out of the mouth, and at the same time raising the body forward. As soon as the patient has taken two or three inspirations of pure air the tension is relaxed, and recovery will take place. Another formidable symptom of danger is when your patient is attacked with syncope while under the influence of the gas. Be sure the air passages are open by pulling the tongue forward. Then, the patient being in a sitting posture, bring the head and body forward with considerable violence, which will generally prove sufficient. You may, however, meet cases which will require more effective remedies. The object is first to get the head on a level with or below the heart, so the blood may flow freely to the brain, which is done by laying the patient on the floor; then throw cold water violently in the face. The most effectual remedy is to place the finger far down the throat, which will produce involuntary retching, and is the most efficient action to bring about restoration, after which treat the patient as in any ordinary case of fainting, giving a little brandy, ammoniated tincture of valerian or aromatic spirits of ammonia, ten to twenty-drop doses in water, and allowing the patient to lie on

the lounge until strong enough to walk in the fresh air, when he or she will soon recover completely.

In the hands of a skilful and careful operator no great risk attends the employment of this anæsthetic, but those who are less skilful, and are inexperienced, should reject cases of great physical exhaustion, or patients with a feeble or fatty heart, indicated by pain and flushed face. The distension of the right cavities, which accompanies the disappearance of the radial pulse, and the general lividity of the features, may be attended with some degree of risk, and the danger is increased when, the muscles of the trunk and limbs being convulsed, the pressure of the contracting muscles upon the veins drives the blood forcibly towards the right cavities of the heart, and so adds to their distension.

Administering Nitrous Oxide to Children.

Dr. Buxton states, that in giving nitrous oxide to children, the face-piece (not so much employed in this country) should be removed with the first sign of jactitation; otherwise, these small bodies become so convulsed that it is difficult to keep them still for operation, and much valuable time is lost in the attempt to place them in a convenient position.

In the administration of nitrous oxide gas it is absolutely necessary that the operator should possess a thorough knowledge of physiology, so as to be able to examine beforehand, and with great care, the heart, the lungs, and the kidneys of the patient to be anæsthetized.

Considering that of all surgical operations, the extraction of a tooth may be looked upon as an operation usually of slight importance, and which only requires some dexterity of hand, and may thus be performed by any dentist, the case is not the same when performed during anæsthesia—that in the latter case, according to the opinion of experts, it belongs incontestably to the class of *major operations.* Under these circumstances, according to the provisions of Article 29 of the Law of Ventôre, XI., Officiers de Santé of France, and with still more reason, dentists who hold no diploma have no right to perform it, except under the superintendence of a doctor.

Annexed are the views of Dr. Th. David, director of the Ecole Dentaire of Paris, on this subject, who has come to the following conclusions:

1. The extraction of a tooth of a person under anæsthesia is to be looked upon as one of the major surgical operations which, by the terms of the law of Ventôre, are only to be performed by doctors of medicine.

2. Officiers de Santé are only entitled to administer anæsthetics under the guidance and in the presence of a doctor of medicine.

3. No one can pretend that an operation which even Officiers de Santê are not allowed to perform can be considered to form part of the practice of the dental art, and be permitted to people who possess no medical qualification of any kind.

4. Dentists who do not hold a diploma and who administer anæsthetics alone incur the penalties edicted against the illegal practice of medicine (Arts. 35 and 36 of the law of Ventôre an XI.), and in the event of an accident, the penalties edicted by Article 319, of the Code Penal, for accidental homicide (homicide par imprudence).

Deaths Under Nitrous Oxide Gas.

The following deaths have occurred since the seven recorded in the publication of our third edition.* The facts as reported are that in London, England, Mr. Lee, aged 25, a man in ordinary health, died in a dentist's chair after the extraction of a tooth for which nitrous oxide had been given. Mr. Lee entered a dentist's surgery and complained of toothache. A neighboring medical practitioner was called in, nitrous oxide gas was administered, the patient went under its influence without anything unusual taking place, and the tooth was extracted. Subsequently the breathing became "heavy," and finally ceased. The patient was placed supine upon the floor and artificial

* The Lancet Commission has collected *seventeen deaths* as having occurred during the anæsthetic use of the gas. Dr. Charles M. Buchanan has stated the mortality of nitrous oxide inhalation is 2 into 10,500,000.—Medical News, Vol. lxii., April, 1893.

respiration was attempted. It is stated that "the throat became so swollen that the mouth could not be closed," and tracheotomy was performed, artificial respiration being practiced for half an hour. The patient, however, never recovered. The gentleman who gave the gas is reported to have said that he had had an experience of between 30,000 and 40,000 cases without a previous accident. He further stated that he had tried the use of ether and nitrite of amyl, which, being cardiac stimulants, would point to there having been some symptoms of circulatory failure. Whether death was purely asphyxial, as the verdict averred, or not, we cannot upon this evidence decide. The necropsy was said to have revealed that the wind-pipe was filled with mucus—a fact which points rather to some irritant being at work. Impure nitrous oxide is a powerful irritant, from the presence in it of higher oxides of nitrogen, and could have produced this result. We are not told whether the patient had just partaken of luncheon and vomited, nor was any statement made as to whether the gas itself was properly prepared and had been used safely with other patients. Casualties, which probably can be counted on the fingers out of many millions of administrations of nitrous oxide gas, have been due to shock, spasm of the larynx, impaction of foreign bodies in the air passages — *e.g.*, blood clot and mucus, fragments of teeth, etc.—or syncope. To which of these classes the lamentable death of Mr. Lee belongs it is impossible for us to say. Recently a death occurred while the patient was awaiting the turn to have the gas, and no doubt fear is a potent element in many deaths put down to an anæsthetic. It has to be remembered that so enormous is the use of this anæsthetic at the present time that with care and skill the risks its use entails may, even in the face of such sad occurrences as the one of which we have been speaking, be taken as infinitely small.—London *Lancet*, March 3, 1894.

Died in a Dentist's Chair.

Buffalo, May 1, 1892.—Mrs. Elizabeth Lipp, a handsome young woman of Clinton street, died in a dentist's chair Saturday night while under the influence of laughing gas. Accom-

panied by her husband, she went to the office of Dr. E. C. Longnecter, early in the evening, to have four teeth extracted. The dentist advised the use of gas, and Mrs. Lipp consented. She did not yield readily to its influence, and the usual dose was increased. She immediately fell into an unconscious state. After three teeth had been extracted the husband grew frightened at the appearance of his wife. Her face had become pallid, her breathing was light, and no pulse could be found. "My God, she's dead," cried the husband as he seized her hands and covered them with kisses.

The dentist assured him that she was all right and then drew the fourth tooth. When he endeavored to restore the woman to consciousness he was horrified that every effort failed. Her husband hurried for a physician, but just as the doctor entered the room the woman died. She had been in the chair only ten minutes. Coroner Ransom will hold an inquest, and it is likely that Dr. Longnecter may have to answer to a jury for criminal carelessness. Mrs. Lipp was the mother of two children, and had been married but five years. Her husband is prostrated with grief, and it is feared he may lose his reason.

Death from Nitrous Oxide.

A death from nitrous oxide is reported from Montreal. A man, aged 24, went to the office of a dentist to have a tooth extracted, and requested to have gas administered. After assuring himself that the patient was not suffering from heart or lung disease, the doctor administered the gas. No sooner had the tooth been extracted than the patient gave a gasp and fell over in the chair. He was placed on the floor and artificial respiration performed, but without restoring animation. The patient was not under the influence of liquor, and five hours had elapsed since last taking food (breakfast). The purity of the gas was tested shortly after the accident by the President of the Dental Association, Dr. Beers, who himself inhaled it from the same inhaler. The verdict of the jury was that the man died from syncope, caused by the administration of gas, and they exonerated the dentist from blame.—*Druggists' Circular*, September, 1890.

Death from Nitrous Oxide.

W. P.; residence Chestnut Hill. Had been for some time suffering from the effects of the grippe. His physician, Dr. M., had done all he could for him on account of the intense pain in the head. Dr. Wm. W. was called in consultation, and discovered a diseased tooth, and thought its removal would perhaps relieve the pain. Accordingly Dr. K. was sent for, and administered the gas with a hooded inhalator. The patient took the gas, and it was not noticed that he became asphyxiated, and that gradually respiration failed. The operator, instead of endeavoring to resuscitate the patient, extracted the tooth, when it was found that the patient was dying, and respiration and heart had ceased their functions. Every means was then employed, but without results.

Deaths from Nitrous Oxide Gas.

Out of the seven deaths reported from nitrous oxide, those who have absolute faith in its non-giving death qualities allow that there are only two well-authenticated cases which they are willing should be classed as true deaths. In this edition we have retained only one of the seven which we reported before, but in this case the operator thought we were a little unfair, so we have received his own statement of the facts as follows:

"The particulars of Mr. C.'s case are these. He called to have two teeth extracted about 12 M., and presented no symptom of any kind contraindicating his taking the gas. He had done so on three or four former occasions. He took the gas well and recovered completely inside of two minutes, expressing himself as really enjoying the experience. He sat in the chair rinsing the blood away with one glass of water, then arose and walked to the washstand to refill his glass, returning to the chair for further rinsing. This he did four times, carrying on friendly conversation and consuming fully twenty-five minutes, during which time nothing appeared to indicate anything wrong. When he had finished, he walked to the mirror and endeavored to see the socket, using his right hand to press back the lips and cheek (the teeth were second and third molars,

right upper). As he put his hand down he closed the fingers, and remarked that his hand felt numb. He looked pale, and I at first thought looking at the wounds had made him faint, and told him to walk over to the couch, which he did, and before three minutes had passed his right side was paralyzed, and consciousness ceased in perhaps ten minutes.

"He lived until five o'clock. The coroner exonerated the operator and the anæsthetic, and gave the verdict of death from apoplexy, which might have been caused by any excitement."

Therapeutic Application of Nitrous Oxide.

Neuralgia, uncomplicated, will sometimes be relieved by a few inhalations of nitrous oxide gas; on the other hand, if a disordered condition of the stomach cause the neuralgic pains, instead of proving a relief it will only aggravate the trouble.

NERVOUS APHONIA.—This peculiar form of loss of the power over the voice, usually the result of hysteria, will be much improved by the patient inhaling a sufficient amount of the nitrous oxide gas to produce a partial loss of sensation and muscular relaxation.

LOCAL PARALYSIS has been benefited, where there was no brain lesion, by the gentle stimulation of the first stage of the gas, or the tingling and stimulating effect on the muscles.

ASTHMA.—This disease, when of a spasmodic character, is often much improved by causing the patient to pass into the stage of relaxation, employing it every other day for a week or two.

EPILEPSY.—When this disease is not the result of an organic change in the brain, spine or other portion of the nervous system, but the result of some peripheral or reflex action, benefit will ensue by the use of the gas for weeks. It should be administered two or three times a week only, to produce the stimulating effects of the first stage of anæsthesia.

Dr. George J. Zeigler,* a friend of the writer, has found the solution of the gas in water of much utility in the treatment of diseased conditions of the kidneys and bladder.

* See his work on this subject.

This gas, we understand, either alone or mixed with oxygen, is employed by certain individuals as a secret remedy—a plausible form of quackery kept up by the most extensive and persistent advertising.

Therapeutics of Nitrous Oxide Gas according to Dr. A. M'Lane Hamilton.

"For the relief of severe paroxysm of neuralgic pain, this gas stands high as a remedial agent. I have used it in cases of severe and persistent facial neuralgia and in common sciatica. When hypodermic injections of morphia have done little or no good, this agent offered relief, not only temporarily, but in another way. Just as oxygen was useful in the hands of Hooper, La Passe, Hill, Demarquay and others, so is dilute nitrous oxide in neuralgic affections, and in such cases the chemical hæmatic action is that which it produces.

"As yet I have not used the gas in the treatment of epilepsy, though I have no reason to doubt its value in a disease which is essentially an anæmia. Dr. Smith alludes to a case reported by Wallihan, who had used mixed nitrous oxide and oxygen with great success.

"There is a variety of insomnia which depends upon overwork and general prostration. Such a case came under my care in the person of the president of a college who was on his way to Bermuda in pursuit of a change of air and scene. He was persuaded to come to me by a patient who had taken the gas. He had not slept for some time, except for a few hours, and then he was tortured by bad dreams. After daily taking four gallons of gas he slept soundly three nights out of four, and there would have been no exception had he not excited himself in preparing for his trip. In other cases the gas acted very badly when it was given at night, for although drowsiness succeeded the administration, there was a secondary stage of excitement of a disagreeable kind; I therefore followed the suggestion of my friend, Dr. Blake, and administered the gas in the middle of the day, and found, as a consequence, that the insomnia was overcome. Probably the beneficial effects arose from a general equalization of the circulation and the removal

of effete nervous tissue from the perivascular spaces. In such examples of insomnia dependent upon slow removal of waste products of cerebral action, the circulation of vitiated blood in consequence of hepatic or renal disease, or depressed tone of the cerebral vessels, nitrous oxide gas was indicated and tried with success. In clearly asthenic cases, however, in which the sleeplessness depended upon excitement, vascular engorgement of a congestive character, or active cerebral hyperæmia in connection with hypertrophy of the left side of the heart, and increased vascular tension, the employment of nitrous oxide was contra-indicated, and did no good. In fact, in one case it aggravated the wakefulness.

"In some forms of functional heart disorder I have witnessed results which fulfilled all my anticipations. In cases connected with hypochondriasis its virtues were most apparent, and many an imaginary trouble ceased to annoy the patient when his intellectual functions were restored to a normal condition.

"In one case of functional heart trouble, attended by palpitation, depression, sinking feelings, and an indescribable pang which followed physical exercise, in the person of a well-known literary gentleman of middle age, whose sufferings were dependent upon many years of hard intellectual labor, I was glad to find that after two or three days his trouble disappeared to a great extent, and probably in a younger subject would have vanished altogether. In his case, however, there were probably deeper troubles. For chlorotic young women who suffer from ovarian irregularities, head troubles and palpitation, nitrous oxide does much good.

"The vague muscular pains, irregularity of heart action, loss of appetite, tremor, sinking sensations, and nervous irritability, so common among those who use tobacco to excess, form a train of symptoms which disappear very rapidly under the influence of gas, and the irritability of opium eaters, and those who drink to a degree that brings them to the verge of acute alcoholism, subsides very quickly. For this reason dilute nitrous oxide may be given to persons who suddenly part with their accustomed opium or alcohol, and with a fair show of permanent success, for an agent which not only supplies oxygen but im-

proves the nutrition of worn-out tissue, and supplies at the same time a stimulant without reaction cannot fail to bridge the patient over the period of acute suffering and intense irritability in the beginning."

Dr. Colton on the Safety in Disease of Nitrous Oxide Gas.

"Is it safe in the various organic diseases, such as those of the heart, lungs, brain, etc.? Thousands of invalids have suffered torture for months and years because they dreaded the surgeon's knife, and in like manner other thousands, suffering from some organic or functional disorder of the system, have dreaded the dentist's forceps, and fearing to take an anæsthetic, have for years carried in their mouths a mass of filth, a fruitful cause of disease, which has not only ruined their health and destroyed their happiness, but made them objects of repugnance to all who are so unfortunate as to be associated with them.

"If the above question can be answered in the affirmative; if nitrous oxide is safe for such afflicted ones, it is, certainly, a great boon to suffering humanity.

"Having used it almost indiscriminately for years, I present below the results of my experience:

"Disease of Lungs.—It is a well-established fact that pure nitrous oxide gas is entirely non-irritating to the lungs, and as we have already shown, its action upon the blood is to increase the property of coagulation. A person who is predisposed to hæmorrhage can inhale the gas with entire immunity from danger—indeed, I think with less danger than would attend the operation if no anæsthetic were administered, since the shock to the system is thereby avoided, and there is but a slight increase in the force of the circulation. In a large number of such cases where the gas has been administered for tooth-extraction I have never met with one where any hæmorrhage followed immediately succeeding the operation, nor any in which the after-effects proved unpropitious; and this, notwithstanding a large number have had hæmorrhages previous to the operation, and some immediately succeeding it. I should state here that, in all cases of disease, the effects of the gas are

watched with the greatest care, and if any untoward symptoms present themselves, it has been discontinued, although this has never, in a single case, been found necessary until the patient was sufficiently under its influence to permit of a momentary operation; as for instance, the extraction of a tooth.

"HEART DISEASE.—In this disease the effects should be watched with care, and there will be no danger. The cumulative action of the gas is only for a few seconds, so that if it be withdrawn at any time during the process a reaction takes place in a moment, we might almost say before the patient has time to die; while with ether and chloroform there is a cumulative action for from 20 to 50 seconds after they have been discontinued, and several minutes may elapse before consciousness returns. Although its evanescent character is a great obstacle to its use for long operations, still that is the great safeguard against accident, for the heart's action may be under your control, as the engine is under the control of the engineer. If the pressure is too great, he lets off the steam; if the heart's action is either increased or diminished inordinately, remove the gas and in a moment it resumes its wonted action.

"In two recorded cases the condition of the patient was so critical that I should scarcely have dared to extract a tooth without the use of an anæsthetic, fearing the shock to the system incident to the operation, there being in one case a complexity of diseases—hypertrophy, dilatation and valvular disease, which had been continued for 12 years. He had formerly followed the sea, but had not been able to go upon the streets, without assistance, for several years. He was pale and anæmic, with an irregular and intermittent pulse.

"The administration of the gas was continued only to near the close of the second stage; the patient recovered without any untoward symptoms, and left the office in a few moments declaring he felt better than when he came in. He certainly looked much better, having lost that deathly pallor of face which he had when he sat in our operating chair. The danger in such cases is that the feebleness of the heart's contractile power may cause its action to cease altogether during the period when this power is partially destroyed by the paralyzing action

of the anæsthetic, while the safety lies in the instantaneous reaction after the withdrawal of the gas.

"In CHOREA, HYSTERIA, EPILEPSY and other diseases dependent upon a disordered condition of the nervous system, it is productive of no bad results, unless it be pushed too far; while if only the second stage of anæsthesia be produced, so that it shall act as a stimulant to the nervous system, and not as a depressing agent, it will in many such cases prove a most valuable remedial agent.

"Uncomplicated Neuralgia is oftentimes instantly relieved. I could adduce a hundred instances of the kind, where the patient has sat down with a severe headache and been entirely relieved by a few inhalations of the gas. On the other hand, if a disordered condition of the stomach cause the neuralgic pains, instead of proving a relief it will only aggravate the trouble.

"A lady who had inhaled ether a half-hour previously for the extraction of some teeth, and had been unsuccessful, came to the office with a severe headache; she inhaled the gas, her teeth were drawn, and upon recovery she stated that her headache was entirely relieved.

"HYSTERIA.—The gas, by its stimulating action upon the nerves, has oftentimes proved beneficial in cases that have come under my observation.

"Such patients generally leave the office with hysterical symptoms much less aggravated than before the inhalation. During the operation, the friend in attendance sometimes expresses fears that the patient may have one of her 'nervous spells,' noticing some contortion of the face or movement of the hand as she is waking from a dream; but in a few moments, as soon as complete recovery has taken place, there is usually a calmness of the patient quite surprising to the attendant, she being able to write her name, with as steady a hand as usual, within five minutes of the commencement of inhalation.

"I have the record of an interesting case of a young lady who had not been able to speak above a whisper for several months previous to taking the gas, who, a few days subsequent, called and informed me with the greatest delight that she had been cured, as she could talk now as well as ever.

"The fact that she awoke after the operation crying out may have had some agency in effecting the cure, as she thus learned that she possessed vocal organs and could use them.

"Still, this case, in connection with very many others of a like character, has convinced me that pure nitrous oxide may be employed with great advantage in cases of hysteria ; while, on the other hand, if it be impure, either on account of its being prepared so recently, or for too long a period, or, if persisted in beyond the third stage, it is absolutely injurious.

"ASTHMA.—Asthmatic patients express a sense of relief after inhaling the gas which, in some instances, at least, seems to be of a permanent character. A gentleman of sixty years, whose disease was inherited, and who had been a severe sufferer for many years, was almost entirely relieved for a whole winter by inhaling for a few successive days, once or twice each day, a quantity sufficient to produce the second stage of anæsthesia, although he had not been free from the disease, at this season of the year, for about twenty years.

"PARALYSIS.—Quite a number of patients afflicted with paralysis, in a greater or less degree, have come under my observation upon whom the gas has had a very pleasing effect in stimulating the nervous system to action, and thus restoring the tone of the paralyzed parts more or less completely.

"One such case was that of a gentleman who had, for a long time, been afflicted with paralysis of the bladder. He inhaled the gas, upon several occasions, for the relief of neuralgia. After a few inhalations, the paralyzed condition was much improved, as was evinced by his freedom from incontinence. It is necessary, in such cases, to produce only the second stage of anæsthesia.

"EPILEPSY.—The following cases of epilepsy are of considerable interest:

"*Case* 1.—A young man, 28 years of age, who had inherited the disease, inhaled the gas for six weeks, two or three times in a week. During the first week he had three epileptic attacks ; during the second week, two; during the third, one; and for the three weeks succeeding, not any.

"I presented the case, at the time, at the University clinics,

but have never been able to obtain its subsequent history. Previous to inhaling the gas he had had two or three attacks daily, and he had not been free from them for so long a time for several years. Two years previously he had inhaled the gas for tooth extraction with a favorable result, which he, at the time, attributed to the bromide of potassium which he was taking.

"*Case* 2.—A young lady inhaled the gas as a remedy in the same disease. She recently informed me that she had not had an attack for several months, although before this she had experienced them frequently. She attributes her freedom from attacks to the remedial efficacy of the gas."

Nitrous Oxide and Oxygen as an Anæsthetic in Labor.

The great advantages of nitrous oxide as an anæsthetic have induced various observers to endeavor to find a method of administering the gas continuously, so as to keep up the anæsthetic influence for a sufficient length of time for the performance of surgical operations.

Paul Bert, some years ago, made experiments with animals in a chamber of compressed air, a mixture of nitrous oxide and oxygen being inhaled.

He found that anæsthesia could be kept up for a long period, and he urged the construction of such chambers for operating upon the human subject.

Some few experiments were made in minor surgery, but nothing on a large scale was attempted on account of the expense, etc.

In 1881 Dr. Si Klikovich, in St. Petersburg, made some experiments on himself with a mixture of nitrous oxide and oxygen, in the proportion of eighty to twenty, without any increase of atmospheric pressure, with a satisfactory result. He also used it for alleviating the pains of labor, and found it very successful and perfectly safe, the great objection to it being its expense, and the cumbersome nature of the required apparatus.

Professor Zweifel, of Erlangen, erected the necessary apparatus for the supply of the mixed gases to the accouchement

ward of his obstetric clinic. He finds it best to administer the gases continuously during the latter part of the labor, when the pains are most severe, not, as was practiced by Klikovich, merely giving the gases when signs of approaching pain appeared.

Though this treatment had been adopted in sixty patients, no retardation of the process was observed.—*B. Med. Journal*, November 7, 1885.

The Field Widening for the Use of Nitrous Oxide Gas.*

James Brown Burnet, A.M., M.D., of Newark, N. J., kindly furnishes the following report of some cases treated by him with nitrogen monoxide, together with notes upon his method of exhibiting it, and upon its probable future usefulness :

" Having during the past nine or ten years used very extensively and successfully in my specialty (diseases of the nasal passages, throat, and lungs) compressed air, oxygen, and more especially *nitrous oxide* (prepared by the S. S. White Dental Manufacturing Company), I cheerfully furnish a few notes of cases in which the latter gas, given systematically and perseveringly, has effected the most beneficial results. It has been my invariable rule to administer the nitrous oxide in small doses, a few deep inhalations with periods of rest between, thus securing, not its anæsthetic but its tonic effects. I believe the profession is just awakening to the wonderful therapeutic value of this agent, not only in diseases (especially those of a catarrhal nature) of the nasal passages, throat and lungs, but also in nervous prostration, neuralgia, chronic headaches, languid circulation, insomnia, feeble lung power, partial collapse of the lung with non-resolution or pleuritic adhesions after pneumonia or pleurisy, nervous diarrhœa, or in nervous exhaustion after long-continued fevers, etc. I acknowledge that I am an enthusiastic believer in nitrous oxide inhalations, having seen so much benefit from them in my own practice ; and I the more cheerfully

* Therapeutic Uses of Oxygen and Nitrogen Monoxide, Pamphlet, p. 143. The S. S. White Co.

furnish these few lines, as I believe the field for their use is daily widening, and that in a few years this treatment administered scientifically, methodically and judiciously mixed, as Opie mixed his colors, '*with brains*,' will be the treatment with our best practitioners, and will supersede in part, if not wholly, the present general nauseating stomach medication, and thus give that much-abused poor organ a little wholesome rest, which surely is 'a consummation devoutly to be wished.'

"I will report a few of the more prosaic cases, chronic in nature, of every-day occurrence, happening in my own office practice.

"CASE I. *Old Pleuritic Adhesions.*—Phœbe Y., spinster, aged 51; for last eight years has been greatly troubled with shortness of breath; dull, heavy pains in right side, which were aggravated by deep inspirations; has been treated by various physicians for suspected liver disease, muscular rheumatism, etc. Careful questioning elicited the fact that eight years ago she had acute pleuritis, since which time she has been troubled as above. Diagnosis, after careful physical examination, *old pleuritic adhesions*, which would account for all the symptoms.

"Treatment: ten gallons of N_2O, once each day, for one month; then administered every other day for another month, and every third day for the third month, with steady improvement of symptoms. Not one drop of medicine, but good nourishment, deep pulmonary gymnastics (inspirations), and plenty of out-door exercise, Discharged cured in three months; no pain; no dyspnœa remaining; no recurrence; adhesions broken down and absorbed; free play of both lungs; ever since a most grateful patient.

"CASE II. *Acute Irritative Painful Catarrhal Bronchitis.*—Rudolph G.; aged 27; engraver; suffocative, paroxysmal cough, with bloody, muco-purulent expectoration for six months; loss of flesh and strength; dyspnœa, etc., has been treated for phthisis pulmonalis, pertussis, laryngitis, etc.

"Diagnosis, *Irritative bronchitis.* No pulmonary complications, but respiratory murmur over both lungs. Patient greatly weakened. Treatment: Best of nourishment; out-door

exercise; calisthenics; salt-water bathing, with vigorous rubbing night and morning of whole body with flesh-brushes. Nitrogen monoxide, ten gallons, twice a day for fourteen days, then once per diem for one month, after that every other day for two weeks; no medicine. Discharged in two months perfectly cured; no recurrence; works all the time; lungs and bronchi sound; meet him frequently upon the streets, always well, smiling and happy.

"CASE III. *Nervous Diarrhœa.*—Mrs. N.; aged 47; much emaciated; has been troubled for four months with nervous diarrhœa; great nervous prostration; partial loss of control over sphincter ani; sent to me for oxygen treatment by Dr. E. Dr. E.'s diagnosis confirmed. No medicine given; treated entirely by N_2O, ten gallons each day, in divided doses, for one month, then three times a week for three weeks, afterwards twice a week for next fourteen days. Discharged cured in about nine weeks; flesh and color regained; normal condition of health restored. In good condition since.

"CASE IV. *Sluggish Circulation.*—Mrs. W.; aged 45; dull headaches; constant drowsiness; sense of formication in right arm and leg, numbness, tingling, etc.; cold hands; clammy feet. Treated by inhalations of N_2O, ten gallons each day for three weeks, every other day for five weeks, then twice per week for one month. Discharged in three months cured of all her disagreeable symptoms (she had had these sensations for over a year previously); circulation perfect; headaches gone; perfect cheerfulness regained.

"CASE V. *Nervous Prostration.*—Geo. P.; aged 42; stout, robust man, but completely overcome by the cares of business life; was recommended to me by one who had been entirely relieved of a severe catarrhal laryngitis by the same treatment. Patient was moody, irritable and melancholic; suffered from insomnia; friends feared loss of reason, etc.; had been under the best of professional treatment for two years. Commenced with ten gallons of N_2O once per day, increased to twenty gallons per diem for one month; occasionally thirty gallons in small divided doses, then every other day for one month, the third month twice a week. The only medicine used was wine of coca. Re-

sults truly marvellous. Cure now complete; sleeps and eats well; works hard; head clear; is happy, bright and strong.

"These cases could be extended indefinitely, as I am using the N_2O daily and extensively."

Then follows the report of two cases very similar to the above.

On Insanity or Mental Disturbance following an Operation where a Prolonged Use of an Anæsthetic had been Employed.

In our former editions we recorded the experience of Dr. George H. Savage, in which violent delirium, with insensibility of the conjunctiva, ended, in three weeks, in complete dementia, followed in a chronic drinker immediately upon nitrous oxide inhalation.

Dr. F. A. Ashford also reports a case of a young woman who grew faint and dizzy shortly after waking from nitrous oxide, passed into a condition of disturbed consciousness, and found, when she came fully to herself, that her left arm was useless. It appears to Dr. Wood, and we fully agree with him, therefore, that nitrous oxide should never be administered when there is marked degeneration of the vessels, and that the danger of its employment would be especially great if there should be an aneurism with feeble walls.—*Amer. Journ. Med. Sci.*, vol. lvii., 1869.

We have received the following reprint from Dr. Wood, and, while not agreeing with him in his views on the subject of the action of nitrous oxide, we are glad to place it before our readers.

On the Action of Nitrous Oxide and of the Mixture of Nitrous Oxide and Oxygen.*

Any reader of the last edition of my work on Therapeutics knows that I believe that nitrous oxide acts as an anæsthetic by

* By H. C. Wood, M.D., Philadelphia, Pa., Professor of Materia Medica, Pharmacy and General Therapeutics, and Clinical Professor of Nervous Diseases, University of Pennsylvania. (Reprinted from the Dental Cosmos for May, 1893.)

shutting off oxygen, and that this belief is founded upon the following facts: that, as established by Jolyet and Blanche, and by Elihu Thompson, an animal will live in nitrogen, in hydrogen, or even in a vacuum, as long as in pure nitrous oxide; that, as shown by myself (see pp. 104, 105), the circulatory phenomena of nitrous oxide anæsthesia are very similar to those which are caused by the inhalation of pure nitrogen or by mechanical asphyxia; that, as shown by my own experiments, as well as by those of the French observers above named, the addition of sufficient oxygen to nitrous oxide prevents any anæsthesia; and finally that, as shown by the French observers, coma is not developed until the oxygen in the blood is reduced to three or four per cent. On the other hand, Paul Bert states that a mixture of eighty-five per cent. of nitrous oxide and fifteen per cent. of oxygen, under a pressure of at least two atmospheres, will produce anæsthesia, and has devised an apparatus which, it is stated, has been used practically in Paris for the purposes of surgical anæsthesia. Further, in the experiments of Jolyet and Blanche, and in my own experiments, never less than ten per cent. of oxygen was mixed with the nitrous oxide, and in some of the experiments the amount of oxygen in the mixture equalled that present in the atmosphere.

Under these circumstances, it has seemed to me well worth while to make a series of experiments to determine the effects of the addition of a small percentage of oxygen to the nitrous oxide inhaled, and to add to the main object of the research the investigation of the relations between the time required to produce anæsthesia in an animal by the inhalation of nitrous oxide, and that necessary for the production of anæsthesia in the same animal by complete exclusion of air; or, in other words, by mechanical asphyxia. In these experiments a tracheal canula was first tightly tied in the trachea of a dog, then connected with a rubber tube, which, in turn, could be either connected with a graduated gasometer, or be completely stopped up by means of a tightly driven-in cork. By the use of mercurial valves the inspired and expired air were entirely separated, so that the animal never re-breathed the gas mixture.

I have made five experiments in which pure nitrous oxide was

first breathed, then, after a sufficient lapse of time, nitrous oxide containing three per cent. of oxygen, then nitrous oxide containing five per cent. of oxygen, and then mechanical asphyxia was produced. In each case two or more inhalations of the pure or oxygenated nitrous oxide were given, and in reporting below the results of the experiments, the average time of the several inhalations in each case is given. The test for the completion of anæsthesia was the complete abolition of all conjunctival reflexes. As in the dog these reflexes are very persistent, it is probable that loss of consciousness and sensation were reached a little before the time noted ; but the corneal reflex affords the best practical test for comparative judgment, and I therefore employed it. The following are the records of the five experiments made :

Experiment I.—Small Dog.

Pure Nitrous Oxide.

Min.	Sec.	Remarks.
0		Inhalation began.
2	30	Corneal reflexes gone to light touch.
3		Reflexes gone entirely.
0		Inhalation began.
2	35	Corneal reflex gone to light touch.
3	45	Reflex gone entirely.

Nitrous Oxide with Three Per Cent. of Oxygen.

Min.	Sec.	Remarks.
0		Inhalation began.
4	45	Corneal reflex gone.
0		Inhalation began.
4		Corneal reflex impaired.
4	30	Reflexes gone.

Nitrous Oxide with Five Per Cent. of Oxygen.

Min.	Sec.	Remarks.
0		Inhalation began.
6		Reflexes unchanged.
0		Inhalation began.
12		Reflexes not impaired.

Mechanical Asphyxia.

Min.	Sec.	Remarks.
0		Cork put in tracheal tube, so as to prevent any entrance of air into the lungs.
2	15	Corneal reflex gone.

Experiment II.

Pure Nitrous Oxide.

Min.	Sec.	Remarks.
0		Inhalation began.
2	10	Corneal reflexes gone.

Nitrous Oxide with Three Per Cent. of Oxygen.

Min.	Sec.	Remarks.
0		Inhalation began.
2	30	Corneal reflexes impaired.
4	30	Corneal reflexes very feeble, but not gone; respiration almost arrested.
5	30	Corneal reflexes gone.

Nitrous Oxide with Five Per Cent. of Oxygen.

Min.	Sec.	Remarks.
0		Inhalation began.
9		Corneal reflexes impaired.
11		Corneal reflexes much impaired.
12	30	Corneal reflexes same.
14		Corneal reflexes almost gone.
15	30	Corneal reflexes gone; respiration regular and good. Half a minute after detaching apparatus corneal reflex had become about normal.

Mechanical Asphyxia.

Min.	Sec.	Remarks.
0		Cork put in tracheal tube.
2	30	Corneal reflexes gone.

Experiment III.

Pure Nitrous Oxide.

Min.	Sec.	Remarks.
0		Inhalation began.
2	20	Corneal reflex gone.

Pure Nitrous Oxide.

Min.	Sec.	Remarks.
0		Inhalation began.
2	10	Corneal reflexes gone.

Nitrous Oxide with Three Per Cent. of Oxygen.

Min.	Sec.	Remarks.
0		Inhalation began.
2	30	Corneal reflexes impaired.
4	30	Corneal reflexes very feeble, but not gone; respiration almost arrested.
5	30	Corneal reflexes gone.

Nitrous Oxide with Five Per Cent. of Oxygen.

Min.	Sec.	Remarks.
0		Inhalation began.
9		Corneal reflexes impaired.
11		Corneal reflexes much impaired.
12	30	Corneal reflexes same.
14		Corneal reflexes almost gone.
15	30	Corneal reflexes gone; respiration regular and good. Half a minute after detaching apparatus corneal reflex had become about normal.

Mechanical Asphyxia.

Min.	Sec.	Remarks.
0		Cork put in tracheal tube.
2	30	Corneal reflex gone.

Experiment IV.

Pure Nitrous Oxide.

Min.	Sec.	Remarks.
0		Inhalation began.
1	30	Corneal reflex gone.

Nitrous Oxide with Three Per Cent. of Oxygen.

Min.	Sec.	Remarks.
0		Inhalation began.
3		Corneal reflexes gone.

Nitrous Oxide with Five Per Cent. of Oxygen.

Min.	Sec.	Remarks.
0		Inhalation began.
6		Corneal reflexes much impaired.
10		Corneal reflexes almost gone.
19		Corneal reflexes gone.

Mechanical Asphyxia.

Min.	Sec.	Remarks.
0		Cork put in tube.
1	50	Corneal reflexes gone.

Experiment V.

Pure Nitrous Oxide.

Min.	Sec.	Remarks.
0		Inhalation began.
1	45	Corneal reflexes gone.

Nitrous Oxide with Three Per Cent. of Oxygen.

Min.	Sec.	Remarks.
0		Inhalation began.
2	50	Corneal reflexes gone.

Nitrous Oxide with Five Per Cent. of Oxygen.

Min.	Sec.	Remarks.
0		Inhalation began.
23		Corneal reflexes gone.

Mechanical Asphyxia.

Min.	Sec.	Remarks.
0		Cork put in tube.
1	40	Corneal reflexes gone.

The following table gives the results obtained in these experiments. Where one or more inhalations of the same character were made in the single experiment, the average of the respec-

tive times required to cause complete anæsthesia is given in the table :

TIME REQUIRED FOR ANÆSTHESIA.

Exp. No.	Pure Nitrous Oxide.		Nitrous Oxide with 3 Per Cent. Oxygen.		Nitrous Oxide with 5 Per Cent. Oxygen.		Mechanical Asphyxia.	
	Min.	Sec.	Min.	Sec.	Min.	Sec.	Min.	Sec.
1	3	27	4	37			2	15
2	2	10	5	30	15	30	2	30
3	2	15	5	30	15	30	2	30
4	1	30	3		19		1	50
5	1	45	2	50	23		1	40

In taking the average of the five experiments it will be noted that two minutes thirteen seconds were required to produce complete anæsthesia with pure nitrous oxide gas, while in mechanical asphyxia the same result was reached in two minutes nine seconds. The correspondence between these two periods is very close—so close, indeed, as to give the very strongest evidence of the truth of the theory that nitrous oxide anæsthesia is really a form of asphyxia. As the carbonic acid in the blood in mechanical asphyxia must count for something, it is remarkable that the nitrous oxide period was only four seconds longer than that of the asphyxia.

The effect of the introduction of a little oxygen into the nitrous oxide was very pronounced; three per cent. of oxygen caused the average time required for the production of anæsthesia to lengthen from two minutes and thirteen seconds to four minutes and seventeen seconds, while the introduction of five per cent. of oxygen increased the period to eighteen minutes and fifteen seconds. This effect of oxygen is, of course, a very strong corroboration of the asphyxia theory.

After the completion of the five experiments I made one trial of the effect of the inhalation of a mixture of nitrous oxide with eight per cent. of oxygen. The inhalation was continued during half an hour, at the end of which time the corneal reflexes, although impaired, were still quite active. The supply of gas giving out, my experiment was ended, but certainly it was continued long enough to decide that eight per

cent. of oxygen will in the dog indefinitely postpone the production of complete anæsthesia. That the system is affected, however, was shown by the fact that mechanical stoppage of the tube at the end of the half-hour produced very few struggles, complete insensibility occurring in less than a minute.

The results which I have reached in this paper indicate that theoretically it is possible to get a mixture of oxygen and nitrous oxide which will contain sufficient oxygen to maintain for a length of time the vital function, and yet have so little oxygen that consciousness would be lost. The zone, however, between unaccompanied loss of upper brain function and loss of respiratory and heart power is such a narrow one that it does not seem to me probable that the surgeon can avail himself practically of the existence of this zone; the danger of passing suddenly from anæsthesia into sensibility, or from partial into complete asphyxia, would always be too imminent. Another difficulty would lie in the great length of time required to produce anæsthesia with a combination of oxygen and nitrous oxide. It is not possible by experiments upon the lower animals to determine accurately the exact percentage of oxygen which the surgeon should mix with his nitrous oxide, when essaying to make use of the zone just above spoken of. My experiments seem to show that in the dog six per cent. of oxygen in the nitrous oxide is probably the nearest approach to a practical anæsthetic mixture that can be made. It is probable that in man a larger proportion of oxygen could be used, as I was rather surprised to find the powerful effect upon myself of two or three deep inhalations of nitrous oxide containing five per cent. of oxygen.

The conclusions which seem to be reached by the present research are, first, confirmation of the view that nitrous oxide produces anæsthesia by cutting off the supply of oxygen; second, that a mixture of nitrous oxide with oxygen does not seem to be available as a practical anæsthetic.

We have already stated our reasons why we differ from Dr. Wood in so far that nitrous oxide has powers as an anæsthetic, producing sleep, freedom from pain, and power to resist the use of the knife.

PART THIRD.

ALCOHOL U. S.—ETHYL ALCOHOL.
(CHO.CHOH.)

CHAPTER IV.

Alcohol, Different Kinds—The Alcohol Recognized by U. S. Pharmacopœia—Absolute and Dilute Alcohols—The Alcohol in Whiskey, Wine and Brandy—Amylic Alcohol—The Physiological Action of Alcohol—The Influence of Alcohol on the Kidney and Liver—Strychnine in Chronic Alcoholism—The Toxic Action of Alcohol—In Moderate Doses the Action of Alcohol on the Heart—Heat-producing and Waste-preventing Action of Alcohol—Physiological Action of Alcohol—Alcohol as an Anæsthetic—Views of Richardson, Link and Others—Toxicology—Treatment of Acute Alcoholic Poisoning.

There are some (about) twelve different kinds of alcohol, as follows: Allylic, amylic, benzylic, beetylic, caprylic, cetylic, cinnamylic, melyssyl, etc. But the one which is recognized by the U. S. Pharmacopœia is ethyl absolute and diluted. The absolute alcohol has a specific gravity of 0.796, and should not contain but one per cent. of water. It is a colorless, volatile liquid, boiling at 172° F., not congealed by cold at 166° F. It is only employed for chemical purposes or for a local drying, hardening, or deodorizing agent. In aural surgery it acts upon aural polypi, depriving them of their watery constituents; also for preparing the diluted alcohol.

The next form is ethylic alcohol deodorized, U. S. P., specific gravity 0.816. This is perfumers' alcohol—cologne spirits. The commercial alcohol is ordinarily free from fusel oil and purified.

The alcohol dilutum contains forty-eight to six per cent. by volume of absolute ethyl alcohol, and having a specific gravity of 0.936. This is the alcohol which is employed for preparing tinctures and other pharmaceutical preparations. This form can be used internally in low forms of fever and debility, assists and aids digestion, and checks nausea of sea-sickness. Dose 60 to 240 m. in two to six times its volume of water.

Alcohol is found to be the active agent in the officinal spiritus frumenti, or whiskey, and spiritus vini gallici, or brandy, which are obtained, respectively, by the distillation of fermented grain and fermented grapes, and should contain from forty-eight to fifty-six per cent. of absolute alcohol. Alcohol in the form of wine, brandy and whiskey is a food within the limit of ʒj to ℥j per day.

Another alcohol, which is also used in this country and European countries for adulterating, and contains much amylic alcohol, is made from Indian corn, potatoes, beets, wood, etc. It has a burning, acrid taste and unpleasant odor. It is of a dark-brown color; but this is removed by filtering through lime, charcoal and alum.

Physiological Action of Alcohol.

It has long been recognized that when persons are under the controlling influence of alcohol, either in the form of wine, gin, whiskey, or brandy, they may be cut, bruised, and bones broken, without expressing or experiencing much or any pain. These various agents were employed, as we have before stated, long before any true anæsthetic was discovered, by making the individual intoxicated. Whiskey is still quite common in the hands of our railroad surgeons, being used as a stimulant to produce reaction after a shock, and was and is resorted to alone or in conjunction with chloroform.

When alcohol is inhaled, its effects are developed in four distinct stages:

First Stage.—There is excitement, flushing of the body, and dilatation of the pupils; after a time there follows languor, and the muscular movements become irregular.

Second Stage.—Muscular prostration and labored breathing,

attended by deep sighing movements and rolling over of the body.

Third Stage.—Complete insensibility to pain, with unconsciousness to all external objects, with inability to exert any voluntary muscular power. The breathing now becomes embarrassed and blowing, with bronchial râles, due to the passage of air through fluid that has accumulated in the finer bronchial passages. The heart and lungs, however, even in this stage, retain their functions, and therefore recovery will take place if the conditions for it be favorable. Also, if the body be touched or irritated in parts, there will be a response of motion, not from any knowledge or consciousness, but from reflex action. During all these stages there is no violent convulsive action, but, step by step, a reduction of temperature; so, at last, the loss of heat will become dangerous, for the cool body cannot throw off the water freely, and therefore fluid collects in the lungs, and there is a risk of suffocation, as from drowning. If the administration of the alcohol be continued when the third degree has been reached, there is a fourth stage, which is that of death. The two remaining nervous centres, which feed the heart and respiration, cease simultaneously to act, and all motion is over. If, however, after the third stage of insensibility the administration of the spirit be stopped, recovery from insensibility and prostration will take place on one condition, that the body be kept warm for several hours.

Alcohol as an Anæsthetic.

Alcohol has been employed in the form of whiskey as an anæsthetic, alone, even in capital operations. The following is the experience of Dr. John Link.*

In his first case, which he reported, a great shock was sustained, in a railroad accident, by a brakeman on the Indianapolis and St. Louis Railroad. Whiskey alone was given. The amputation was down near the hip; also an operation on the

* Pamphlet of 8 pages. Prepared for the International Medical Congress. By John E. Link, M.D., Terre Haute, Ind., Chief Surgeon of the Vandalia R.R., etc.

foot through the metatarsal bones. The patient asked for water, and in other respects seemed rational during the operation, but died soon after from shock. He then reports four cases, with details of temperature, pulse, etc.; amputation of right arm, right foot, secondary of two left legs. He states these are given in detail as typical cases. If left to choose between whiskey and chloroform, alcohol would be his preference, administered rapidly, preserving a more normal or physiological condition of the system than either chloroform or ether.

There is less drunkenness at the same stage of insensibility to pain with the former than with the latter.

With alcohol we have hyperæmia of the base of the brain, as evidenced by the flushed face and fulness of the features about the eyes, mouth, and the lips, etc. His views are that it has a counteracting influence against shock and anæmia of the brain from the loss of blood, etc. He defends himself against the charge that such administration of alcohol leads to tippling and drunkenness. He knew of no case where such had been the result, and, on the contrary, he might cite many instances where a repugnance and distaste for whiskey had been the result, even in those where an appetite for it existed previously, the very smell of whiskey being associated with the operation and suffering.

Desiring to have the opinion of a gentleman who is, and has been for many years, one of the surgeons to one of the most extensive railroad companies in the United States, I submitted Dr. Link's pamphlet for his opinion, which we now publish, as the matter is of great practical importance:

"In regard to the report of Dr. Link, I must say that I cannot fully indorse his ideas for the reason that he gives credit to the 'Alcohol,' which, in my opinion at least, is partly due to the chloroform.

"Before administering chloroform to a patient, I invariably give 2 to 3 ozs. whiskey, with from $\frac{1}{3}$ to $\frac{1}{2}$ gr. morphia, place the subject on the table (in case of amputation), and see that *all* clothing is loose and the patient's head low; then on a towel or large napkin, folded in 4 to 6 plies, I pour on about

ʒss chloroform, and allow the patient to inhale it slowly at first, adding ʒss from time to time, as required, until completely under its influence. In this way it is seldom that more than ℥ss is required in an ordinary amputation.

"If the patient does not go under the influence rapidly, I place my open hand over the towel and exclude the air for a few inhalations, which always has the desired effect, when the hand should be removed."

The late Valentine Mott, in his essay on "Pain and Anæsthetics," objects to those agents which are apt to disturb the stomach, and reports the following case:

"I well remember a case of amputation of the thigh which occurred a few years since in my own practice, where the attending physician, notwithstanding repeated cautions, administered brandy to the patient so freely as to induce vomiting, thus interfering with the continuance of the reaction, and inducing a fatal result. It was an extensive cannon shot wound of the knee-joint, and the operation was performed on the third day from the injury, before collapse had sufficiently passed off."

These various alcohols have all a toxic action when given in sufficiently large doses. The general effect they produce on the organism is epilepsy, amblyopia, insanity and paralysis, affecting the nerve centres in the inverse order of their development. Their lethal power and the symptoms they produce are modified by the physical characters and the quantity administered.

Yet it has been found that in moderate doses alcohol caused great increase in the rate and force of the cardiac beat and corresponding rise of the arterial pressure, and that these phenomena were not affected by previous division of the pneumogastrics, of the accelerators of the spinal cord. There is also, in these small doses, a sensation of warmth and an increase of heat, while in very large doses there is a fall of temperature from an increase of oxygen consumed and of carbonic acid eliminated.

The exhibition of alcohol has been found to lessen the excretion of urea or tissue waste, while it increases bodily weight. Alcohol is a most valuable remedy in typhoid fever and diphtheria, and as a gargle, with water and glycerine, one of the best in laryngitis.

Conclusions as to the Physiological Action of Alcohol.

In a recent extended experimental study of the physiological actions of alcohol by a young physiologist,* late of this city, he arrived at the following conclusions, in which we fully agree with him:

"1. Alcohol in small amount excites, and in large doses depresses, both the peripheral motor and sensory nerves.

"2. Excessive quantities cause a spiral degeneration of the axis-cylinder of nerve fibres.

"3. Reflex action is first increased and afterwards diminished by an influence exercised by the drug upon the spinal cord and nerves.

"4. In small amounts stimulates the cerebral functions; it afterwards, especially in large quantities, depresses, and finally abolishes them.

"5. Alcohol causes lack of co-ordination by depressing both the brain and the spinal cord.

"6. In toxic doses alcohol produces hyperæmia of brain and spinal cord, especially of the lumbar enlargement of the latter.

"7. Small doses of alcohol produce increased rapidity of the cardiac beat; large amounts a depression of the same. In either case the effect is brought about mainly through direct cardiac action.

"8. The drug in small quantities causes a rise of the arterial pressure by a direct action upon the heart; in large amounts it depresses the arterial pressure similarly through cardiac influence.

"9. In large doses alcohol enhances coagulation of the blood; in toxic quantities it destroys the ozonizing power of this fluid, causing a separation of the hæmoglobin from the corpuscles.

"10. Alcohol in small quantities has little or no effect on the respiratory function. In large doses it produces a depression of both rate and depth of the respiration through a direct action on the centres of the medulla oblongata.

"11. The drug kills usually by failure of the respiration.

* David Cerna, M.D., Ph.D., Demonstrator of Physiology, Med. Dept. of the Univ. of Texas. Proc. Pan-American Congress, p. 220, Vol. I.

"12. On the elimination of carbon dioxide alcohol exercises a varying action, sometimes increasing, sometimes decreasing, such elimination.

"13. The action of alcohol on the amount of oxygen absorbed also varies and may be said to be practically unknown.

"14. The drug lessens the excretion of tissue waste both in health and disease.

"15. In small amounts alcohol increases the bodily temperature; in large doses it diminishes the same. The fall of bodily temperature is due mainly to an excess of heat dissipation caused by the drug.

"16. Alcohol, in sufficiently large amounts, has a decided antipyretic action, but for the purpose of reducing abnormal high temperature should not be used.

"17. In moderate amounts alcohol aids the digestive process.

"18. Alcohol diminishes the absorption of fats.

"19. The drug exercises a varying action on the amount of urine secreted; but it probably increases the activity of the kidneys.

"20. In large doses, or when continuously used for a long time, alcohol produces cirrhotic changes in the liver and paralysis of spinal origin. It also causes insanity, epilepsy and other maladies.

"21. Alcohol is mainly burnt up in the system when taken in moderate quantities, but when ingested in excessive amounts it is partly eliminated by the breath, the kidneys, and the intestines.

"22. Alcohol is a conservator of tissue, of general or of vital force; and may, therefore, be considered a food."

The Influence of Alcohol on the Kidney and Liver.*

"I have selected only those cases where the person died more or less suddenly; where the history and general appearance clearly showed that death was due to alcoholism, and where all

* The Pig-backed or Alcohol Kidney of Drunkards. Med. News, October 2, 1886. By H. F. Formad, M.D., also pamphlet by the same author.

other factors in causing death had been carefully excluded as far as possible.

"Through the kindness of the coroner of Philadelphia, who, of necessity, is called upon to issue death certificates in such cases, I have had, during the last two years, the opportunity of making observations which some time ago numbered *two hundred and fifty cases* belonging strictly to the category above referred to, and mainly from my own autopsies. In this city, with a population of about one million, there are annually nearly two thousand cases of sudden death subject to legal inquiry. The proportion of cases of alcoholism appears thus remarkably large."

Anatomical Considerations.—I have met with two varieties of the kidney lesion now to be described:

First, a hard cyanotic form of the "pig-backed" or alcoholic kidney, in cases of sudden death; and

Second, a soft œdematous form of the same, in cases where death had been delayed.

First Form.—In nearly all persons who died more or less suddenly from the direct effects of alcohol, I found the kidneys to present the following appearances: The kidneys are always above the normal size; they are often from one-third to one-half larger, and are sometimes even double their usual size and weight. They are longer and thicker than normal, while their width is diminished so that the natural, characteristic flat kidney, or bean-shaped form, is changed to a swollen, rounded, sausage-like, or "pig-backed" appearance or form. They are bluish-red or livid in color from being engorged to their utmost capacity with venous blood, reminding one of the rounded, enlarged appearance of animal kidneys when over-filled by some artificial injection mass. In most cases these "pig-backed" kidneys are elastic, but quite hard when freshly removed from the body; but unlike the cyanotic induration from heart disease, they gradually become softer, unless the renal vessels are at once tied to prevent escape of blood from them.

On section the cut surface presents the same dark-red or livid appearance as seen in the cardiac form of renal cyanotic induration. While in the latter, however, the pyramids of the medul-

lary substance are especially congested, in the alcoholic cyanosis the whole kidney substance is almost uniformly dark red. Dark blood oozes from the cut surface, and blood extravasations can be often seen by the naked eye, principally below the capsules.

Second Form.—The other form of alcoholic kidney referred to was met with in persons who had died some time after a debauch (suffering from a few hours to a few days from delirium tremens previous to death). The kidneys of such subjects are found to be soft and flabby from œdema, and they are less red; otherwise presenting the same appearance as the hard variety of alcoholic renal cyanosis, including the "pig-back" shape of the kidneys.

Microscopy.—Sections were made from a number of specimens of the alcoholic kidneys, care being taken to examine microscopically all the different structural parts of these organs. For brevity sake, only the essential changes will be referred to.

The cortical and medullary portions of the kidney appear to be similarly affected, but, as a rule, the latter less so than the former.

In the hard, cyanotic form of the alcoholic renal cyanosis the Malpighian glomeruli of the cortical portion are highly congested, and extravasated blood is seen within many of the Malpighian capsules; some are enlarged to double their normal size, but the majority appear rather compressed by the surrounding swollen uriniferous tubules and by the over-distended bloodvessels. The latter (both arteries and veins) show thickened walls, and are deeply congested nearly everywhere throughout the organ. The stellate veins in particular are enormously distended and plugged up by blood corpuscles as in thrombosis. The lymph spaces beneath the capsules, as well as around the tubules, are also dilated and distended, and are either seen empty, or they contain extravasated blood. In some sections the kidney structure gives the appearance of a cavernous change.

The epithelium of the convoluted tubules is cloudy, swollen, opaque, and the nuclei obscured by granules, which, however, become cleared up upon the addition of a solution of sodium

hydrate. The epithelial cells appear to be double their normal size, and although no visible desquamation or proliferation of the cells could be noted in any one of the typical specimens examined, it appears that the lumena of the tubules are obliterated completely, as seen in transverse sections of the tubules.

In the straight tubules of the medullary portion the same changes have been noted, but are less marked.

The connective-tissue elements of the pure alcoholic kidney show no pronounced hyperplasia. In the sections of most of the kidneys it is hardly perceptible. Sections in which the epithelial lining was forcibly removed by means of a camel's-hair brush showed the connective-tissue to be dense, stiff, often pigmented, but only moderately increased in a few places around the bloodvessels.

The connective-tissue increase was notably prominent only in sections derived from occasional specimens, which showed at the same time other evidences of inflammatory changes (Bright's disease and in cases complicated with heart disease). I do not remember having seen in one of the sections of the pure alcoholic affection tube-casts or blood within the uriniferous tubules.

In sections from the soft, œdematous form of the alcoholic kidney the minute changes were essentially the same, but not so marked as those described above. Extravasations of blood were less frequently seen, while the connective-tissue elements appeared occasionally more or less proliferated. In sections from some cases, however, no other change could be observed than the very prominent cloudy swelling of the epithelium peculiar to all the specimens of the alcoholic kidney.

In alcoholism we must look to the kidney substance itself for the cause of the obstruction to the renal circulation, because there is, as a rule, no cause for it outside of the kidney; no disease of the thoracic viscera and no thrombosis of the veins.

Dr. Formad states that he has heard Virchow say that "beer drinkers have *hypertrophied* kidneys." This view is also expressed by other pathologists, but no explanation is offered, nor have the anatomical peculiarities of the kidneys of drunk-

ards been described. In relation to the pathogenesis of the alcoholic renal cyanosis, the following explanation suggests itself:

"It is well known that in persons who ingest great quantities of fluid, particularly alcoholic beverages in dilute form, the kidneys are strained to overwork. The quantity of urine normally passed by such persons is enormous so long as the kidneys act at all, and can at times be favorably compared with the quantity of urine passed in diabetes. It is evident that such overwork must invite a constant active (arterial) hyperæmia, which, of necessity, produces a hypertrophy, due to a cloudy swelling of the epithelium and an overgrowth of all the structural constituents of the kidneys. A long continuance or a constant repetition of these conditions leads eventually to a passive (venous) congestion, which persists or increases or subsides according to the repetition and the duration of the debauches of the drunkard. The renal circulation of the blood is retarded by the pressure of the swollen epithelium of the uriniferous tubules, as exerted upon the vessels, a pressure which the thicker walls of the intertubular arteries and arterioles can resist more readily than the soft and thin walls of the corresponding veins. There appears to be also thrombosis of the stellate veins. The exit of blood is thus retarded, while the arterial pressure continues unabated and keeps the kidneys constantly overfilled with blood. Eventually the kidneys are filled to their utmost capacity with blood overcharged with carbonic acid, and in consequence also with serum, which, leaking out of the obstructed veins into the renal lymph spaces, makes the kidney tissue œdematous; blood extravasates also, and adds to the firmness, redness and roundness of the organ. Finally, the renal circulation comes to an entire standstill, coincident probably with a suppression of the urinary secretion."

Statistical Remarks.—Of the 250 cases of sudden death from alcoholism so far analyzed, 176 were men and 74 women. The hard, red form of the "pig-backed" kidney was found in men, principally in the younger and middle aged, while the softer œdematous form was more common in men of advanced age and in the women. The kidneys of which Bright's disease

was coincident with the alcoholic lesion were mostly those of persons in advanced life.

The alcoholic renal lesion was nearly equally divided between persons of Anglo-Saxon and German descent, and, so far as I could perceive, equally between whiskey and beer and ale drinkers. I cannot speak about wine drinkers, who in this country belong to the higher classes of society, and are seldom reached by the scalpel of the pathologist.

The brains of confirmed drunkards should be studied by pathologists. The claim that chronic drunkenness is a form of insanity may perhaps be found to have some foundation.

The Medico-legal Aspect.—A thorough knowledge and correct interpretation of the post-mortem appearances of alcoholism is perhaps to no end more important than when the life or welfare of a fellow-creature is at stake.

His experience has since taught him that cirrhosis with contraction of the liver is at least as rare an affection in drunkards as it is in "teetotalers," and that the traditional "hobnail" or "gin-drinker's" liver is not diagnostic at all, *while the large, fatty liver is one of the most important signs of alcoholism.* The facts are that in 250 drunkards he found the *enlarged, fatty liver 220 times*, and the contracted, *cirrhotic liver but* 6 *times.*

Often when a drunkard falls dead on any occasion a cry of murder is raised, especially when bruises are found upon the body. It is here that a familiarity with the post-mortem appearances of fatal alcoholism is particularly necessary, and nowhere can ignorance on the part of the examiner do more harm than here.

The constant occurrence of the "pig-backed" or alcoholic kidney in hard drinkers who perished from their drinking, and the rarity of kidneys of such character in those who are not confirmed drunkards, induced me to regard the kidneys as a valuable sign in post-mortem diagnosis; and next to the presence of alcohol in the stomach, they are, together with the large, fatty liver, the most valuable proof that alcohol was operative or had contributed in *producing death.*

The "pig-backed" or alcoholic kidney, while a valuable diagnostic sign of the *effects* of the prolonged abuse of alcohol,

may not show itself in persons who had been but moderately addicted to the use of alcohol, and in such case alcoholism should not be given as *the* cause of death.

Toxicology.

Cases of acute alcoholic poisoning occur during every few months by persons drinking very large quantities, and more especially young persons. The treatment consists in the evacuation of the stomach, keeping the body warm and in motion with friction by the wet towel, and the use of the alternate hot and cold water bag.

Strychnine in Chronic Alcoholism.

From experiments we feel justified in drawing the following conclusions: 1. Strychnine undoubtedly neutralizes the intoxicating and narcotic effects of alcohol. 2. It enables large quantities of alcohol (when necessary) to be taken for a considerable stretch of time, without causing the usual organic lesions which follow the use of alcohol alone. 3. There are, however, limits beyond which the alkaloid itself becomes injurious to the organism, being a powerful poison. 4. Therapeutically, strychnine and the salts of gold should be used in all forms of alcohol ism. 5. It may be regarded as a powerful prophylactic against-alcoholism. The usual dose is the $\frac{1}{60}$ of a grain repeated at intervals of from three to six hours. In all classes of cases it must be employed with caution. The antidote to strychnine poisoning is animal charcoal or bone black, given in water.

CHAPTER V.

Ethyl Ether—Manufacture—Chemical Reaction and Composition—Tests of Purity, Inflammability—Ether Fortior—Tin or Glass in Preserving Ether—Inflammability of Ether—Influence of Ether on the Brain and Pulse—The Ordinary Method in Use for the Administration of Ether: Towel, Cone and Inhalers—Precautions to be Employed Before and After Using Ether, and Treatment of Dangerous Symptoms.

Ethyl Ether.

Ethyl Oxide, the Ether of Commerce.—A liquid composed of 74 per cent. of ethyl oxide, and about 26 per cent. of alcohol containing a little water (U. S. P.). Its specific gravity is 0.750.

Ethel Fortior, which is a liquid composed of about 94 per cent. ethyl oxide, and about 6 per cent. of alcohol containing a little water and of a specific gravity of 0.725 at 15 C. (59° F.):

$$\text{Ethyl Oxide, Ethyl Ether, } \left.\begin{matrix} C_2H_5 \\ C_2H_5 \end{matrix}\right\} O.$$

This body, commonly called "ether," is manufactured on a large scale by heating a mixture of strong alcohol and concentrated sulphuric acid to 140°. The reaction takes place in two stages: in the first, ethyl, sulphuric acid, and water are formed:

$$\left.\begin{matrix} C_2H_5 \\ H \end{matrix}\right\} O + \left.\begin{matrix} H \\ H \end{matrix}\right\} SO_4 = \left.\begin{matrix} C_2H_5 \\ H \end{matrix}\right\} SO_4 + \left.\begin{matrix} H \\ H \end{matrix}\right\} O.$$

The ethyl, sulphuric acid acts at 140° upon another molecule of alcohol; hydrogen and ether change places, and ether and sulphuric acid are formed:

$$\left.\begin{matrix} C_2H_5 \\ H \end{matrix}\right\} SO_4 + \left.\begin{matrix} C_2H_5 \\ H \end{matrix}\right\} O = \left.\begin{matrix} H \\ H \end{matrix}\right\} SO_4 + \left.\begin{matrix} C_2H_5 \\ C_5H_2 \end{matrix}\right\} O.$$

The ether and the water produced are distilled off, whilst the sulphuric acid remains behind, ready to convert another quantity of alcohol into ether.

The Chemical and Physical Properties of Ether.

Ether is colorless, very volatile, inflammable, both it and its vapor, which latter is twice as heavy as ordinary air, and sinks therefore to the floor, which is important to remember; the vapor becomes ignited when a light has to be used, or a heated metal. It is soluble in alcohol; its odor is garlic-like, strong and pungent. Its taste is hot, slightly soluble in water. Ether must be kept in the dark and in well and carefully prepared tins. When in ordinary use, keep in an opaque glass bottle; for if kept in a hot place, or in the tropics, it is apt to change by absorption of water, undergoing decomposition and developing acetic acid, making it unfit for inhalation. A tin form of bottle has been found very useful in ordinary cases.

The following are some of the methods of determining if the ether is pure for inhalation:

1. Ether, if pure, forms a clear mixture with oil; but if it contains much water or alcohol, an emulsion will result.
2. Water is also detected by adding tannin; for when water is present the mixture becomes syrupy, while, if absent, the powdered tannin remains unchanged.
3. Alcohol, if present, gives a red stain, with crystals of fuchsine; it also increases the specific gravity.
4. Acids, sulphuric and sulphurous, when found in it, are detected by the precipitates they give with barium chloride; also an acid which produces a deep red color upon the addition of an iron salt.
5. Fusel oil may be detected by leaving a greasy stain on paper, and, when inhaled, produces a burning and choking sensation—in some cases almost suffocation.

The Inhalation of Ether—Etherization, Anæsthesia.

Where ether is inhaled freely, mixed with too much air, it produces intoxication, with roaring and buzzing in the ears,

varying in its effects upon different individuals. In some persons it causes depression, with weeping; others, elevation of spirits, indicated by shouting, laughing, singing; others disposed to fight or strut about declaiming, imagining themselves upon the stage. When still semi-conscious, there is a feeling as if one's immediate surroundings were afar off, with visions and illusions. In this first stage the patients will open their eyes, and a slight noise or loud talking will arouse them.

If now almost all air is withdrawn, and the patient breathes deeply and long, it brings about sooner or later the second stage of complete unconsciousness or ether narcosis; but still there is muscular rigidity. As soon as this passes off, complete anæsthesia takes place, when the patient lies quiet, with slow and regular automatic respiration, and the arm, when elevated, will fall as if paralyzed, and the eye, if touched, will not wink. Now and then we have a slight stertor in the breathing. This is the time for operation and the partial withdrawal of ether, giving the patient sufficient ether to keep him fully under its influence.

Very deep, stertorous respiration, due to paresis of the muscles of the palate, should be the signal for allowing air to mix with ether vapor or for the entire withdrawal of the anæsthetic. The usual appearance of the face of the patient during etherization is reddish, lips especially; if very marked pallor and lividity show themselves, indicating failure of heart action, the ether is to be stopped at once, and the feet of the patient elevated and the head depressed until the color returns. Another important sign of danger is what is termed shallow breathing; the respiration, from being slow and regular, becomes very much quickened, and then becomes slower and slower, until it gradually ceases or intermits for long intervals. In such case, stop the inhaler and admit cold air, or apply the vapor of aqua ammonia to the nose; or to strike the chest with the corner of a wet towel, wrung out of ice-cold water, applied to the uncovered chest with some little force, or drop a little of the ether on the open chest, will generally cause the patient to make a sudden gasp, and rouse the respiratory function to action. If these measures fail, then resort must be had to artificial

respiration, and the prevention of great reduction of heat, as the lungs are the chief eliminators, the kidneys only doing a part, and yet, if they are diseased, it is apt to produce great distress, and may be the cause of death.

Precautions to be Employed Before and After Using Ether as an Anæsthetic.

Ether should not be inhaled immediately after a full meal; indeed, it is better to take only a biscuit or cracker, or a glass of wine or a teaspoonful of brandy and water, or a scruple of bromide of potassium in water, half an hour before, always avoiding for several hours previous the risk and annoyance of a full stomach. Nothing like solid food should ever be allowed a feeble patient before inhalation for twenty-four hours. If nourishment is necessary, let it be of liquid character, like beef tea, as solid food, not digested, has been the cause of death in more than one person.

Perfect quiet should be enjoined on all around the patient, as noise, or even loud talking, interferes with the perfect and rapid action of the anæsthetic. Nothing like a tight band or garment should prevent the free action of the throat or chest, or interfere with the muscles of respiration. False teeth should always be laid aside until after the inhalation is over.

An examination of the kidneys should always be made before using ether, as they are the active agents in eliminating ether from the blood, and if they are unable to perform this office, and if the skin is cold, moist, and inactive, death will supervene by accumulation of mucus in the lungs, or congestion of the brain, as in true Bright's disease of the kidneys.

Avoid all excitement to the patient from fear, sight of instruments, too many spectators, noise of any kind, etc., all of which tend to induce shock. Have appliances for resuscitation at hand, and plenty of fresh air during the administration of the anæsthetic. In ether the respirations and heart need to be watched during and after anæsthesia, and also prevent the reduction of temperature by hot bottles of water, etc., in the later stages of narcosis from ether.

Inflammability of Ether.

Treatment of Dangerous Symptoms.—1. Nelaton's plan suggests immediate inversion of the patient in case of heart failure, and *artificial respiration, keeping it up for some time.* 2. Inhalation of gtt. v.–x. of nitrite of amyl may be given early, the tongue being drawn out to lift the epiglottis, by elevating the jaw (Nancrede). 3. Stimulation, in case respiration is affected, but not entirely suspended, should be employed by means of either atropine, ammonia to the nostril, cold towel, or injection of ammonia into the veins, or ice in the rectum. 4. Galvanism, if employed, may be administered by the following methods: Herapath's method (Lancet, 1852). The positive pole is placed to the nostril and the negative pole over the diaphragm. A reflex action is thus excited between the fifth pair and the pneumogastric. This is used chiefly in case of respiratory failure or general galvanic action.

Numerous accidents have come to our knowledge in which the ether was ignited, and, although causing no actual injury, produced much fear and confusion.

Dr. Squibb has seen ether take fire at a measured distance of fifteen feet between the source of escaping vapor and the source of fire. This ignition of ether vapor is apt to occur while applying the actual cautery.

All agents that produce inebriation, like alcohol, only increase the collapse, and the patient must be kept warm while under its influence, or the temperature will sink below the normal, the skin become cold and clammy, with symptoms of collapse. The pulse-rate falls, the breathing becomes embarrassed, and an increase of secretion takes place in the lungs, and death occurs from pulmonary œdema and respiratory paralysis, just as in drunkards who are exposed to cold. On account of the similarity of their action, alcoholic stimulants should not be given where a patient appears to be sinking from ether administration.

Alcohol and ether, the more closely their effects on the lower animals are studied, the more closely are they seen to correspond. Atropia and digitalis, on the other hand, are of some value, but their effects have been greatly magnified; they could

be given in much larger doses than we are accustomed to and without harm.

In considering the causes of death from ether we must not forget that patients sometimes die of heart failure, collapse, or shock. The following means have been found valuable in such cases: A hypodermic of strychnine administered half an hour before the anæsthesia.

Cases in which Ether Should Not be Employed as an Anæsthetic, Except by an Expert or with the Greatest Care.—The conditions rendering anæsthetics dangerous are: Fatty degeneration of the heart, a prominent contra-indication where there is pain in heart.

Physiological Action of Ether.

The following experiment was made, allowing an animal fully to recover from the mixed anæsthetic, and placing it under the full effects of Squibb's ether fortior (in the University of Pennsylvania laboratory, in the presence of Prof. Reichert, Dr. Thomas and the writer).

Ether was crowded on it until the respiration ceased and the heart almost stopped beating; then a solution of 100th of a grain of sulphate of atropia was introduced, to determine if it had any power to stimulate the heart or restore respiration in this stage; but it produced no such results, and the animal was dead.

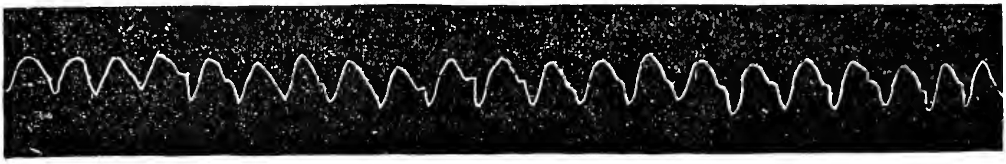
If the same amount of caution is employed in the use of this powerful agent, as in the use of chloroform, the number of deaths would be less. It must always be borne in mind that in full anæsthesia, no matter what agent is employed, there is a suspension of life forces, and but a step to death.

The administration of atropine may be resorted to, but morphia, subcutaneously injected, will increase the risk with ether, not so much with chloroform. There are many individuals who have idiosyncrasies, and cannot bear even what is known as a small dose of morphia without great disturbance of the stomach or faintness.

It has been suggested to add atropine to the morphia, but the experiment just related will demonstrate that it will not relieve the heart when fully under the influence of the stronger

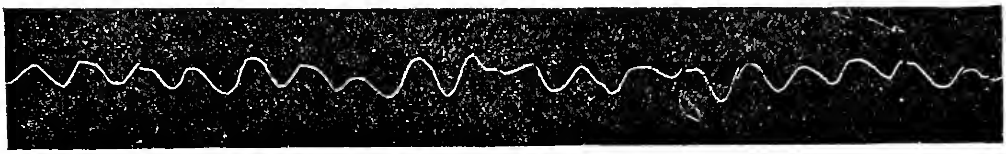
ether. There are no agents which relieve the irritation of the broncho-pulmonary mucous membrane so well as keeping the

PLATE 21.



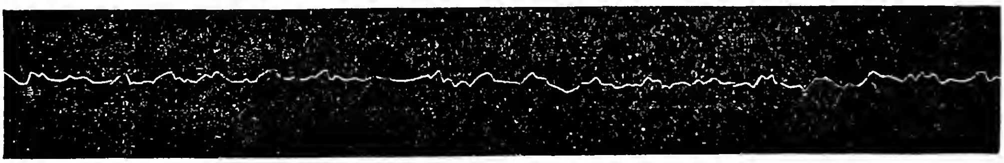
Ether, First Stage.

PLATE 22.



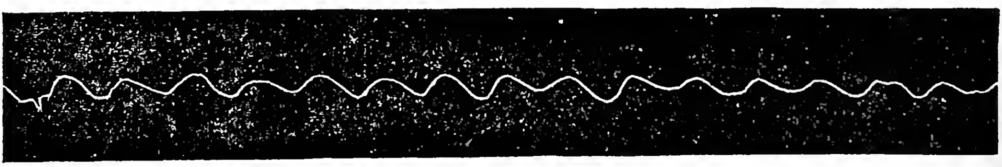
Ether, Second Stage.

PLATE 23.



Chloroform.

PLATE 24.



Bromide of Ethyl.

skin warm and free from moisture or draughts. Above all, no one should give the ether who has not some practical experi-

ence and is not desirous of witnessing the operation. Let his whole attention be given to the patient, and never crowd the ether after the patient has become fully anæsthetized, but keep it off at a distance, so that the patient may get a small portion of it.

The foregoing is a more recent series of sphygmographic tracings. There will be found a decided difference in the pulse and heart in these tracings: ether in Plates 21 and 22, chloroform in Plate 23, and bromide of ethyl in Plate 24.

It will be noticed how much freer from influence upon the heart *ether* is, and how distinct and free from dangerous dicrotic impressions compared with chloroform, which depresses the action of the heart. Hydrobromic ether is not considered quite so dangerous as chloroform.

The Action on the Brain, Heart and Circulation by Ether.

The functions of the cerebrum or brain are first affected before those of other portions of the nervous system. After a more prolonged inhalation the anterior or motor centres soon fail to respond to mechanical irritation, yet the functions of the medulla oblongata are performed.

If the inhalation of ether is still further carried on, the sensory and finally the motor functions of the medulla oblongata are involved, and death occurs from a paralysis of the respiratory centres of the heart. Louget states that he found the sensory functions abolished very early, but he has never failed, in any stage of the narcosis from ether, to get a response from the anterior part of the cord by employing powerful galvanic currents. The elevation of the pulse line shows the stimulating property of the ethereal influence.

Plate 25 represents the excited pulse writing of a small and nervous female previous to etherization and operation.

Plate 26 represents the pulse writing of the same patient when steadied by etherization. The contrast is remarkably favorable.

Plate 27 represents the pulse writing of a healthy young man

of 22 previous to operation for artificial pupil, an affection which had not interfered with his general health.

Plate 28 represents the same when taken under full etherization, and after the completion of the operation. A comparison

PLATE 25.

PLATE 26.

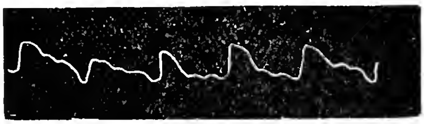


PLATE 27.

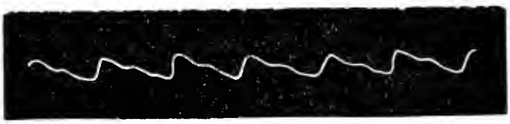
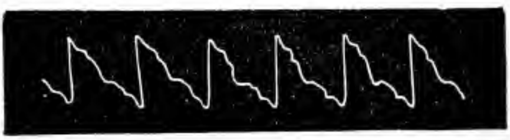


PLATE 28.



of this pulse writing with that of the natural soft pulse, will be ample evidence of the safety of etherization in its action on the heart.

The Action of Ether upon the Circulation.

According to Dr. Wood, "It is firmly established by the coinciding results of very many experiments performed by various observers, that during etherization there is usually a pronounced

rise in the arterial pressure, which is commonly maintained even through a prolonged narcosis, and may continue after manifest failure of respiration. Sooner or later, if the inhalation be continued, the rise of arterial pressure is followed by a fall, which may progressively increase until the manometrical needle reaches almost zero. There have been very few careful studies of the details of the action of ether upon the circulation, but such facts as we have go to show that the primary influence of the drug is to stimulate both vaso-motor centres and heart, and that during the stage of low pressure there is depression of the vaso-motor centres and also of the heart. This belief in the primary stimulation of the vaso-motor centres, rests almost entirely upon the research of Professors Bowditch and Minot, made in 1874, and the subject is well worthy of a careful restudy. There is much reason for the belief that in advanced and profound ether-narcosis, the bloodvessels are affected by the direct action of the substance upon their coats."

Most American surgeons give ether as an anæsthetic by a closed cone, in such a manner that the patient breathes the same air over and over again. This is a very unsafe mode, and to it is due, in a large measure, the alarming prostration of the patients while undergoing operations. Some cases present such profound symptoms of shock that the operation has to be suspended until hypodermic injections of brandy, ether and strychnine are given. Indeed, in some cases, it is with great difficulty that the patients are kept from dying on the table, while some die from œdema of the lungs. Fully impressed with this idea, I advise them using Dr. Allis' improved inhaler, and have thus far found it to act promptly, safely and economically.

Allis' Ether Inhaler.

We present plates of the apparatus of Dr. Allis for the administration of ether. This instrument has been in use in the United States and Europe for several years, and may be said to have won the foremost place among the standard instruments.

This and the following plates are two-thirds the size of the manufactured instrument.

It is now made simpler and stronger than the first that were offered to the profession.

PLATE 29.

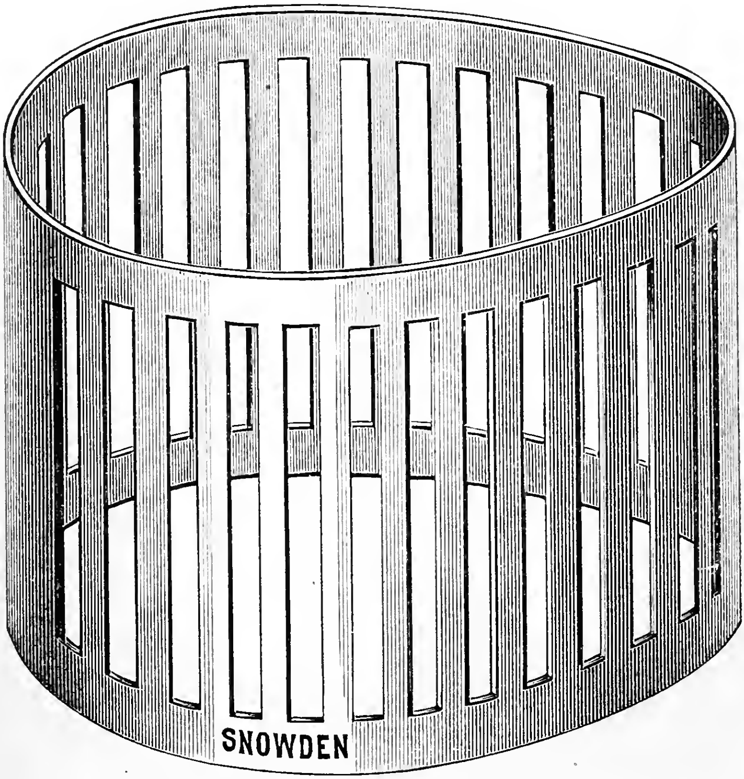
Instrument complete.

DESCRIPTION OF THE INHALER.—Plate 30 consists of a metallic frame sufficiently large to cover the lower part of the face. The bars are nearly a quarter of an inch broad, leav-

ing a quarter of an inch between each and its fellow. The spaces are made by a punch, which removes a section from a solid sheet of metal. It will thus be seen that there can be no danger of the bars giving way, as they would were they soldered upon a band.

In Plate 31 there is a bandage partly laced between the bars. It has been passed from side to side, dividing the instrument

PLATE 30.

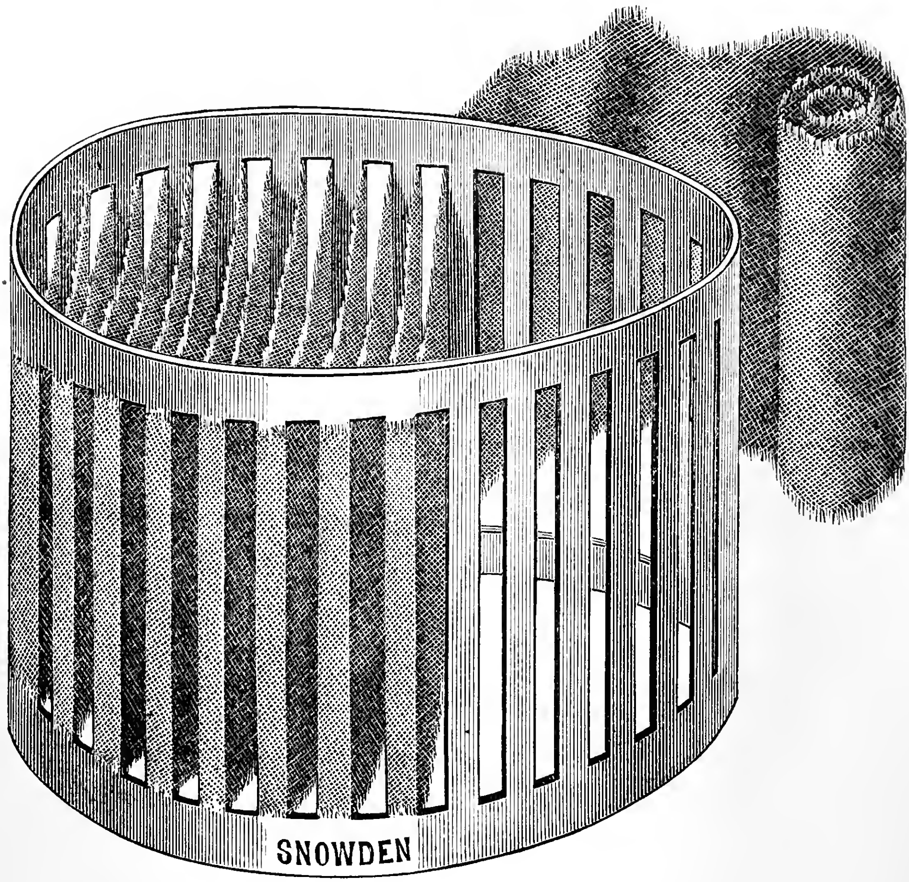


into parallel sections. On the right, a part of the bandage may be seen rolled up. When the bandage has been passed between all the bars, and the hood or cover put on (Plate 29), one can look through the instrument from end to end, and there is a space of nearly a quarter of an inch between the several sections of the bandage.

The advantages of this mode of construction are as follows:

1. It gives the patient (Plate 32) the freest access of the air. It is necessary that *the air should be saturated with the vapor of ether*, by dropping from the bottle.

PLATE 31.



2. It affords a series of thin surfaces, upon which the ether can be dropped and from which it will almost instantly evaporate. In this respect it differs from the sponge, which retains the ether in a fluid state much longer. Should the bandage become soiled a new one can be inserted in a few minutes.

3. By leaving the instrument open at the top, the supply can be kept up constantly if desired; and as *ether vapor is heavier than air*, there is no loss by not covering it. *The top should never be covered.*

PLATE 32.

4. It is kept clean by removing the strips of white muslin each time that it is employed.

Mode of using the inhaler:

1. Place a towel beneath the chin of the patient, as experience has taught that a towel should always be within reach in administering anæsthetics.

2. Place the instrument over the face, covering the nose and chin, and let the patient breathe through it before any ether is

applied. This will convince him that he is not to be deprived of air.

3. Begin with, literally, a few drops of ether; this will not irritate the larynx. Add, in a few seconds, a few drops more, and, as soon as the patient is tolerant of the vapor, increase it gradually to its fullest effect. When the effect of the anæsthetic is apparent, a single layer of a coarse towel may be laid over the nose and mouth, and the instrument replaced. This is a wise precaution against vomiting or spitting.

4. When the patient is fully influenced, it is well to add a few drops at short intervals, and thus keep up a gradual anæsthetic effect.

It was found with Allis' inhaler that the shortest time required to produce complete anæsthesia in a young female patient was three minutes, and the amount of ether employed was only one fluid ounce. The longest period required in an adult female was seven minutes, and the amount of ether used two ounces and a half. In a few instances there was hysterical tendency among the females. If solid food had been taken, vomiting would follow, but after liquid, or light forms of nourishment, vomiting was very rare; not more than one in fifty cases. In temperate males the time for full anæsthesia was from five and a half to eight minutes. Ether consumed: minimum quantity, two ounces; maximum, three ounces. Chloroform cannot be inhaled in this apparatus, as too much is wasted.

Now, in Allis' apparatus there is no chance for the ether to remain in its fluid state, which is the case when a strip of muslin is used, but exposed as it is, on a thin stratum of muslin, it yields its anæsthetic principle promptly.

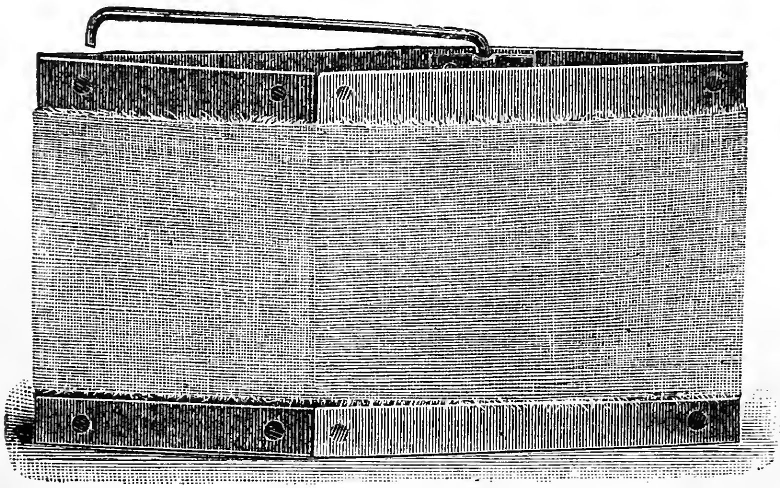
To close this apparatus at the top would necessitate ingress of air at the part surrounding the mouth, for air *must* be admitted.

If it be excluded at the bottom and left open at the top, the advantage of having a constant supply of ether dropping upon the folds is very great.

A Folding Allis' Ether Inhaler.

This inhaler is open to the objection, though to a less extent than other instruments of its class, of being somewhat cumbersome when carried about, and of occupying, therefore, considerable space in the operating satchel. This has been overcome by slightly altering the shape of the inhaler, in such a manner, as to allow of its being folded flatwise. The accompanying plates will show how this is accomplished. Plate 33 represents the inhaler folded, ready for placing in the pocket or satchel, in which shape it occupies about as much room in the pocket or

PLATE 33.



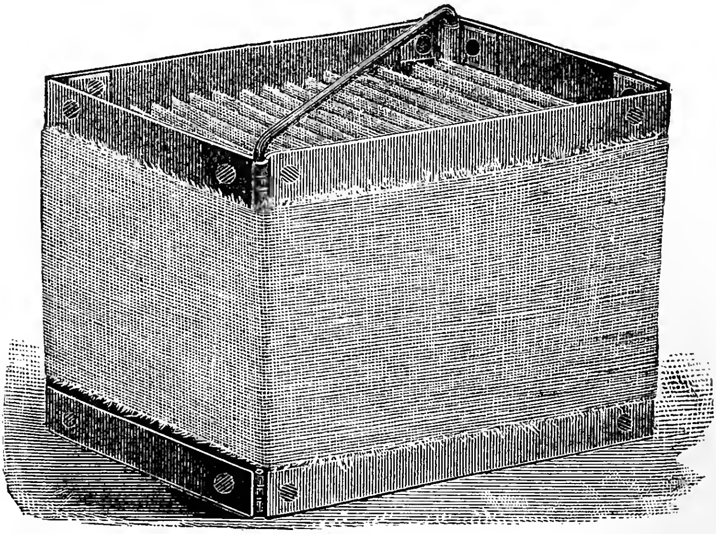
satchel as an ordinary visiting list. By a very simple movement, provided for by bringing together the corners of the metal sides, the two long sides are made to separate from each other, until the shape shown by Plate 34 is formed, in which position it is securely held, by a little bar, which swings over from one corner, to the one diagonally opposite, and fastened, by its bent extremity, into a socket provided for the purpose. The only covering needed for an Allis' Inhaler, is a simple towel folded lengthwise, in which the instrument is inclosed, just prior to its use. This can be procured at the patient's house, and, after the operation, unpinned and thrown aside.

Experiments with Allis' inhaler by Dr. G. H. Coburn, a resident physician of Howard Hospital, carefully recorded all the cases, at our request, occurring during two years, in which this form of Allis' inhaler was employed in the various surgical operations performed in the institution with most satisfactory results.

The objections to this form of apparatus are:

1. That the exhaled vapor is not conveyed to the floor, but is diffused in the air, to be breathed by the operator and his

PLATE 34.



assistants. For a single operation this is not of much importance, but where there are a number of cases the arrangement is not conducive to the comfort of the operator.

2. The bandage of muslin across the bottom becomes clogged with moisture and saliva, and at times by discharges from the stomach, and cannot be so readily removed.

3. Owing to the peculiar arrangement of the muslin strips it is tedious, when it is required for a number of patients, to remove or replace them.

In a conversation with Dr. Allis he stated that he considered the chief merit of his instrument was that it thoroughly and

instantaneously liberated the ether, and that while there was not the least impediment to respiration, yet all the air was impregnated with the anæsthetic.

Neither ether nor chloroform can be inhaled in the pure state.

It is always atmospheric air, impregnated with the anæsthetic, that sustains life and produces anæsthesia.

The expression "give him nothing but ether, exclude the air," are only relative terms; they simply mean *saturate the air as much as possible with the ether. Permit* the patient to have *no fresh air*, but *compel* him to breathe *air charged with ether.*

When he first employed his instrument bystanders would suggest that it be closed at the top, so as to permit no escape of ether.

This will show that the true laws of ether were overlooked; ether vapor, while it will diffuse itself throughout an entire room, is of greater specific gravity than atmospheric air, and tends to the floor.

As germain to this subject, we would direct attention to the following experience recorded by the late Dr. Wm. Goodell, of Philadelphia, in the course of a recent paper, giving a year's experience in ovariotomy:

"One of the chief lessons I have learned from my experience during the past year is to administer ether. Hitherto I have, in common with most American surgeons, given this anæsthetic by a closed cone, in such a manner that the patient breathed her own air over and over again. I am now disposed to think that this is a very unsafe mode, and that to it is due, in a large measure, the alarming prostration of the patient while undergoing the operation. For instance, among the twenty-five cases of last year, cases 70, 71, and 82 presented such profound symptoms of shock that the operation had to be suspended until hypodermic injections of brandy and of ether were made, and some degree of reaction had set in. In cases 70 and 71 it was indeed with great difficulty that the women were kept from dying on the table, while case 85 clearly died

from œdema of the lungs. Now I do not find such alarming symptoms referred to in any reports of cases by British operators. I am therefore forced to the conclusion that either under the strain of rivalry they do not operate in very desperate cases or their mode of administering anæsthetics is a safer one than ours. Fully impressed with this idea, I have lately been using Dr. Allis' improved inhaler, and have thus far found it to act promptly, safely, and economically."

Clover's Small Portable Ether Apparatus.

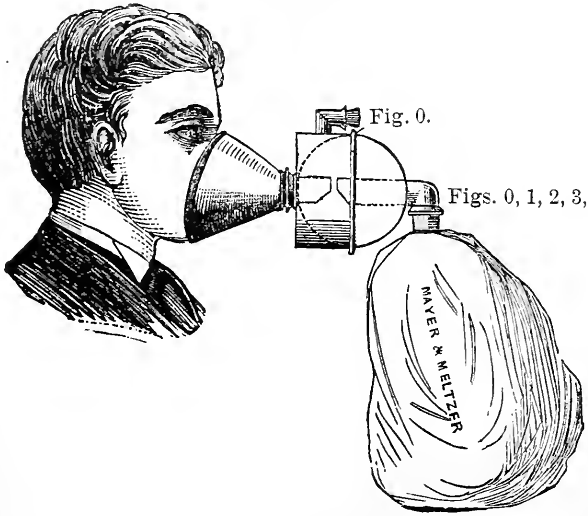
Is a very good inhaler (see Plate 35).

The face-piece is edged with an air cushion. The ether vessel and warm water chamber which surround it and maintain it at the desired temperature for evaporation rotate upon the mouth of the face-piece. When the instrument is first applied the stopper should be opposite the patient's forehead, and the indicator, which travels round the lower end of the water chamber, pointing to the figure 0. The bag should not be placed in position until the patient has taken two or three inspirations; it must then be inflated by blowing air into it, and be fitted to the upper end of the water chamber, as shown in the figure. As the ether vessel is turned round the indicator traveling from 0 to 1, 2, 3, and F successively, the air has to traverse the ether vessel before reaching the bag, and so the patient gets gradually a more and more highly saturated ether atmosphere. Two ounces of ether are poured into the projecting arm before the operation, and these usually suffice for the case. The opening is so arranged as to prevent an excessive quantity being used, and to guard against the possibility of a few drops escaping through the inner openings.

The ether vessel and surrounding water chamber are so arranged that, although the vapor freely escapes, no fluid overflows in whatever position the inhaler may be held. The water chamber is centred by a shaft which communicates with the interior of the ether receptacle, and the vapor escapes into this shaft. From below a hollow metal cylinder fitting to the face-

piece, and above shaped like a clarionet mouth-piece, enters the shaft and closes it, being able at the same time to rotate with the face-piece. To this is fixed the long metal indicator turned at right angles at its extremity. From above a similar-shaped piece of metal is fixed, so that the two "clarionet" pieces are adjacent, the lower one capable of rotation, the upper one fixed. Finally the shaft is completely closed above by the air bag, which is attached to a metal cylinder, closing but freely movable in the shaft. Ether can only reach the

PLATE 35.



patient when the two "clarionet" pieces wholly or partially coincide. When the lower piece moves, the indicator travels with it, and should it point to 0 the ether way is blocked, and then the patient breathes simply air through the shaft in and out of the bag. As soon as the indicator is moved from 0 the "clarionet" pieces cease to shut off ether, and the air enters the chamber and becomes impregnated with its vapor. When F is reached the patient is inhaling ether vapor diluted only by the amount of air exhaled from his lungs. The following is the method of using this inhaler: The appropriate sized face-

piece being selected and two ounces of ether placed in the receiver, the air-bag is removed and the indicator turned to 0. The patient is then directed to inspire deeply, and the face-piece applied firmly but gently. Uniform pressure is well borne, while hard pressure, if unequally distributed, will not be tolerated. When the patient has taken two or three deep breaths, the air-bag is filled by the administrator blowing in air, and is placed into an aperture at the top of the dome, so that the patient now breathes in and out of this bag. The indicator is now moved to 1, so that the patient is breathing one-fourth ether and three-fourths air. A few breaths of such a dilution of ether will accustom the larynx to the irritating vapor, and so obviate coughing, spasm, and the wretched feeling of suffocation which ensues upon presenting a strong ether atmosphere to the patient at the commencement of an inhalation. This tolerance achieved, the indicator is pushed to 2, and the patient then inhales half ether and half air. If this strength of vapor do not distress him, the indicator can be, after a few seconds, carried to 3 (one-fourth part air, three parts ether) and then to F (all ether). The patient will, in from ninety seconds to two minutes and a half, be completely unconscious and ready for operation. Some persons require more ether to affect them, and those who persistently resist taking the anæsthetic by holding their breath, or by taking the shallowest breaths consistent with life, will delay the onset of unconsciousness much longer. These persons also, since they voluntarily semi-asphyxiate themselves by repressing respiratory movements, suffer great additional discomfort from the feeling of suffocation they induce.

As soon as complete anæsthesia is thoroughly established, the indicator may be brought back to 2, and there kept until the operation is over. It may be necessary in warm weather, and in the case of prolonged operations, to renew ether in the receiver. This is easily done by removing the inhaler from the patient's face, loosening the cork, and pouring in a further supply.

The patient will, during a prolonged operation, require the

inhaler taken off his face every sixth breath or so, in order that he may take a few inspirations of air. The necessity for this will be readily recognized by the degree of cyanosis apparent in the face, and by the character of the respirations and the pulse. It should be carefully borne in mind that the amount of an anæsthetic required to produce narcosis is much greater than is needed to maintain that condition. Also the degree of narcosis must be varied in correspondence with the region of the body upon which operative measures are being pursued.

The Cone and its Modifications.

The cone is the chief form in which ether is administered as an anæsthetic in the United States. It is made by folding a starched towel, inside of which is a newspaper, into a cone large enough to go over the mouth and nostrils. The edges are rounded, and the sides pinned together with catch-pins. In the apex of this cone is placed a carefully washed sponge dipped in hot water and squeezed out from time to time so as to prevent freezing of the watery portions of the ether. Ether is poured on the sponge, half an ounce at a time, and repeated, as found necessary, by removing the cone from the patient's mouth. A very convenient cone has been found in the ordinary straw cuff, in which is fixed a sponge, devised by a dentist of Hartford.

Advantages of the Cone for the Inhalation of Ether.—The advantages are: first, the ease with which they are made and removed from the patient's mouth when there are signs of danger; second, the simple cone is never employed with a second patient, which is a great advantage in the way of cleanliness. All heavy or complicated inhaling apparatus are objectionable, as they are apt to become unclean, the valves get out of order, and the patient interfered with in his movements by the weight of them.

The chief objections to the cone and its modifications are that they allow the undiluted ether vapor to impinge upon the larynx, or the sponge to become frozen with wastefulness of the ether.

Dr. Lente's Ether Inhaler.

As early as 1866, Dr. Lente invented a form of inhaler, which has recently been modified. (See Plate 36.) The present improved instrument resembles very much the face-piece of "Waldenburg's apparatus" for the inhalation of condensed and rarified air. The idea of using sheet brass and the india-rubber air-cushion was taken from it. The air-cushion, however, proved a failure, and the inventor substituted hair for stuffing the cushion, which he states retains sufficient of its rotundity to fit the face air-tight.

PLATE 36.

Lente's Ether Inhaler.

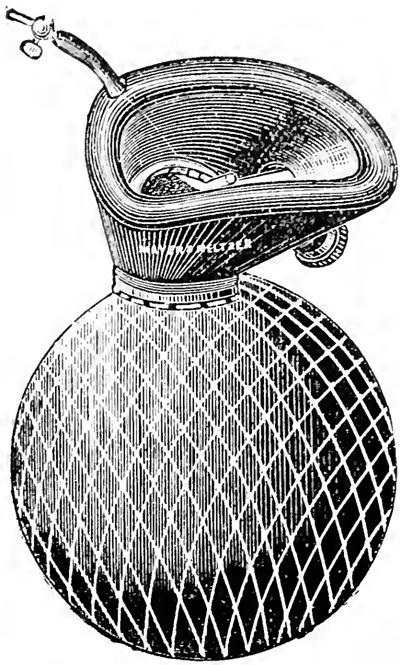
MODE OF EMPLOYING THIS FORM OF INHALER.—A piece of sheet lint is stuffed into the cone, a piece of wire or whalebone is slipped in so as to keep the lint in place and prevent its touching the face. The lint is saturated with ether and placed over the face. There is an opening, fitted with a cork stopper at the apex, large enough to admit air. This is usually closed, but if it is found necessary, the stopper can be removed. The ether can be poured in at this opening without removing the apparatus from the patient's face. Its cleanliness is perfect, as a different piece of lint should be employed each time.

Ether Inhalers—Modifications of the Cone.

One of the same kind as the above is that called after its designer, Dr. Ormsby, of Dublin (Plate 37). It consists of a leather face-piece with cushioned rim, provided with a valve, which can be opened at the pleasure of the administrator; at the top of the face-piece is a cone-shaped wire cage, covered externally with leather, and leading into a soft leather bag, covered by a loose net, which prevents its undue expansion. In

the wire cage a sponge is placed, and upon this an ounce of ether is poured. The apparatus is applied to the patient's face, and he is desired to take a full breath. Even when the valve is kept widely open, the sense of suffocation is so great (the rush of ether vapor producing more or less spasm) that the patient struggles fiercely to escape what appears like impending asphyxia.

PLATE 37.



Ormsby's Ether Inhaler.

Should it be necessary to add fresh anæsthetic during the operation, it is done by pouring ether down a tube which enters the centre of the sponge.

Ormsby's inhaler is open to several objections, *e.g.*, it produces great discomfort by allowing undiluted ether vapor to impinge upon the larynx; the sponge is very liable to freeze hard, and so no evaporation of ether takes place; it occasions great struggling; it is wasteful of the ether. This apparatus is used quite extensively both in England and Ireland.

Hearn's Ether Inhaler.

It is named after its inventor, Dr. Joseph W. Hearn, of Philadelphia, who has had an extended experience in the administration of anæsthetics.

The inhaler (Plate 38) has its outer case, A, made of thin sheet metal, having the lower edge, which comes in contact with the face, covered with rubber.

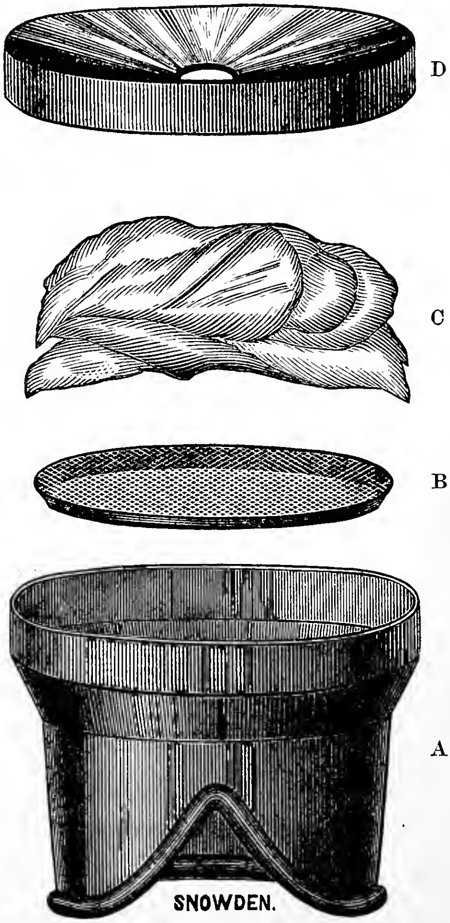
Inside of this case a screen of wire gauze, B, is fitted, which comes opposite the lower joint, as at A.

The lint or Canton flannel upon which the ether is poured is

shown at C, and is held in place between the wire gauze screen, B, and the funnel-shaped top, D.

The object of this inhaler is to furnish an undiluted ether

PLATE 38.



Hearn's Ether Inhaler.

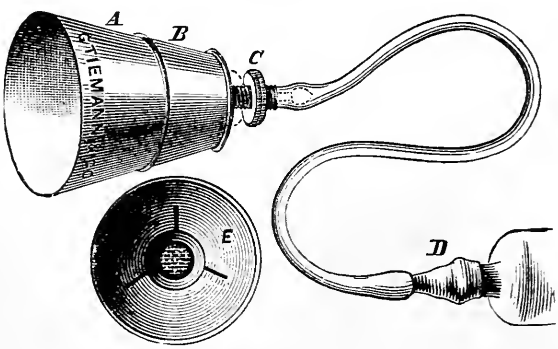
vapor, and prevent, as it should when ether is used, the patient's inhaling the surrounding atmosphere. The time required to produce complete anæsthesia, in ordinary cases, is from five to eight minutes.

Cheatham's Ether Inhaler.

This operates by replenishing the evaporating surface without removing it from the face. A patient cannot be etherized as quickly with it as with the common cone, but with much less ether, and by it you avoid the disagreeable effects of having the ether permeating every part of the office or house in which it is used. Its convenience of application is, also, quite obvious. The ease with which the face-piece (being paper) can be removed immediately after use and thrown away is, we think, a strong recommendation in its favor,

The apparatus consists of a tin cup (Plate 39, A), holding in the inside a sponge as an evaporating surface, and connected from the top by rubber tubing with the bottle that contains the anæsthetic. This tube has attached to its distal end a cap, D, that will fit over the neck of almost any bottle, thus doing away with Lente's graduated bottle.

PLATE 39.



Cheatham's Ether Inhaler.

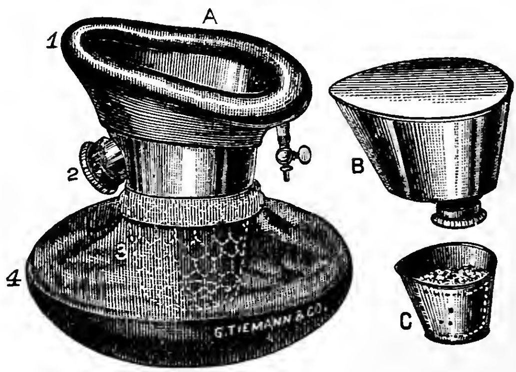
MODE OF USING THE INHALER.—Make a cone of paper, cut the top off, so when the tin cup, A, is slipped inside the top of the cup it will protrude a line or two from the top of the cone. Place tin cup, B, over both cup and cone, screw it down tightly by means of nut, C, and you have the cone held tightly. Attach tube to top of cup and the apparatus is complete. The smaller the cone the more quickly you can get the patient under the influence of the anæsthetic. We would suggest, after the

cone is in position, the bottom should be trimmed, leaving a part of it (we shall call it the back part) that is intended to go over the chin three inches longer than the cup, and sloping forwards and upwards, leaving the front part, intended to go over the nose, about an inch longer than the cup. E gives an inside view of cup A.*

Parkinson Ether Inhaler.

"In presenting this apparatus to the notice of the profession, I wish at the outset to disclaim any idea of misappropriation. The instrument is in principle identical with Ormsby's inhaler, the best points of which have been utilized. A practical experience of some nine years with the original apparatus has

PLATE 40.



Parkinson Ether Inhaler.

A. Inhaler ready for use. *B*. Ether reservoir. *C*. Ether measure, showing sponge inside. 1. Air cushion, inflated. 2. Air cap. 3. Wire net basket to contain sponge. 4. Rubber bag collapsed.

induced me to modify it, so that a compact, efficient and inexpensive inhaler could be obtained by any practitioner. The improvements are the substitution of rigid, instead of flexible

* These various forms of inhalers can be had from the S. S. White Co., Snowden, Gemrig or Kolbe, instrument makers, of Philadelphia; also Geo. Tieman & Co., of New York, and from Codman & Shurtleff, of Boston.

metal in the face-piece, the omission of the ether supply tubes, and the modification of minor details throughout.

"The apparatus consists of a metallic face-piece, the base of which corresponds to the usual facial lines. To the upper part of this is fastened a wire net basket, around the mouth of which, and projecting into the face-piece, is a small gutter, which prevents ether or moisture from dropping on the patient. On one side of the face-piece is an air cap, which exposes or covers a slot, on rotation. A collapsible rubber bag, shaped somewhat like a cranial ice cap, is attached to the face-piece, its elastic neck grasping the apex of the latter, where a groove has been made for its reception. A rubber air cushion fits over the base of the face-piece, maintaining its position by a lip which forms part of the cushion.

"To prepare the inhaler for use, when the temperature of the room is below 65, place a small napkin or towel, wrung out of very hot water, in the face-piece for a few minutes. The sponge, which should have an absorption capacity of two ounces, is soaked, squeezed dry, and placed in the wire net cone, so that every part is above the gutter. The air cushion is then fitted and *partially* inflated. Pour one ounce, by measure, of ether on the sponge, and place the inhaler on the face, with the air slot wide open. This should be closed after three or four inspirations. During the progress of an operation, fresh air is added, as required, in quantities of four drachms. If used for half an hour, it is advisable to remove the sponge and squeeze out the moisture which has formed by condensation.

"The points of superiority claimed for this inhaler are, that it is compact, portable and inexpensive. It is simple in construction, and the rubber portions, when worn out, are easily duplicated. It is most economical in the use of ether, and the unpleasant odor of the drug, by diffusion, is absent. With it the production of anæsthesia is a certainty. The rapidity of its action will equal any apparatus, and there is no method of ether administration which surpasses it in safety.

"Amongst the objections raised are those common to all permanent apparatus: that it is dirty, and that infective matter will adhere to it, or may lodge in the sponge. The simplicity of its

construction admits of a ready and perfect cleansing; and no part will be injured by hot water or antiseptic solutions which are familiar to most practitioners. Against the inhaler *per se* it is urged that the anæsthesia partakes largely of carbonic dioxide poisoning—that this is a source of danger, and an inseparable defect."

Inhaler of Nitrous Oxide Gas or Ether of Codman & Shurtleff, of Boston.

The points for which they claim superiority are:

1. Durability; being made of metal, they are not liable to be easily broken, as so frequently happens to the hard-rubber inhalers, and as they are nickel-plated they retain their brilliant polish without change.

2. For convenience both to the patient and operator. With one hand, the latter can apply the inhaler, and open or close the two-way stopcock, leaving the other hand at liberty to control the patient, or for such exigencies as may occur. As the elastic hood covers both nose and mouth, the patient is saved the necessity of having the nostrils closed either by clamps or the fingers—a part of the operation always very disagreeable, and to very sensitive patients positively frightful, as it produces a feeling of suffocation.

3. Cleanliness. The rubber hood, which alone comes in contact with the face, is easily removed and replaced; and as all the other parts are either metal or hard rubber, the whole instrument can be kept perfectly pure by washing, which is a point of great importance to the comfort of the patient.

4. Durability and accurate working of the valves. Upon this, perhaps, more than anything else, depends the successful administration of anæsthetics. If the exhaling valve does not quickly and perfectly close while the gas is being inhaled, air is taken in with it, and the gas is so much diluted that it very much delays, or wholly prevents, the desired effect.

If, on the other hand, the inhaling valve does not work properly, the patient breathes back into the reservoir a mixture of nitrous oxide and air.

Plate 41 is the inhaler, with a hard rubber mouth-piece, A; the metal hood, B, is used for nitrous oxide gas.

PLATE 41.

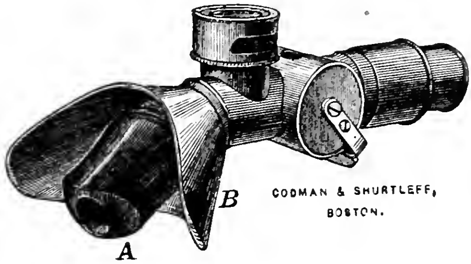
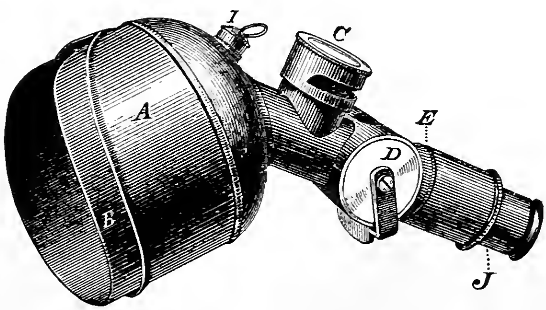


Plate 42 is the inhaler for nitrous oxide gas. A, metallic hood, containing B, flexible rubber hood, covering both nose

PLATE 42.

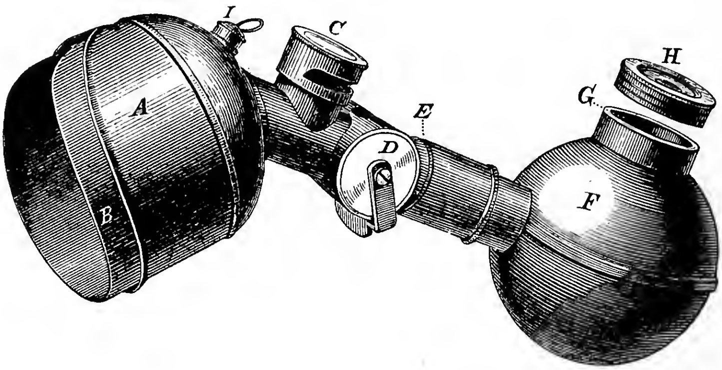


and mouth; C, exhaling valve; D, two-way stop-cock; I, packing, through which a silk cord passes; E, sliding-joint, where J is detached to connect the ether reservoir; J contains the inhaling valve.

Plate 43, the inhaler arranged for using ether. This differs from Plate 42 only in the addition of the hollow sphere, F, which contains a coarse sponge, on which the ether is poured through the opening, G; H, cover closing the reservoir when not in use. This part is attached at the sliding-joint, E, and will fit most inhalers made by Codman & Shurtleff during the last three years. By this arrangement, waste of ether by evap-

orating is prevented, and it is stated that less than half the quantity is required to produce or keep up anæsthesia.

PLATE 43.



The operator also escapes breathing so much of the ether, as he is compelled to do when using it from a sponge or napkin.

The Souchon Auxiliary Injector for the Uninterrupted Anæsthesia in Operations upon the Face and Mouth.*

"All surgeons know the trouble, anxiety, and danger of operating upon the face and mouth on account of the necessity of removing the face-piece through which the anæsthetic is administered so as to uncover the field of operation and enable the operator to proceed; soon after the removal of the face-piece the patient recovers from the effects of the anæsthetic and the operator has to stop for the face-piece to be reapplied; and so on during the whole of the operation. All these drawbacks and delays become very much worse when the patient happens to be one of those unfortunates who respond badly to the effects of the anæsthetic, or who often wake up quickly from a deep

* Read at the meeting of the Southern Surgical and Gynæcological Association, at Washington, D. C., on November 12, 1895, by Edmond Souchon, M.D., of New Orleans, La.; Professor of Anatomy and Clinical Surgery, Tulane University, Fellow of the American Surgical Association. Abstract from The Medical News, November 23, 1895.

anæsthesia and become almost unmanageable. It is a very sorry sight, that of an operation half completed, and an unruly patient bleeding freely and spurting blood all around by the wild movements of his head. His life is then at stake from the impossibility of completely controlling the hæmorrhage all the while and of completing the operation in time.

"It has been my ill-luck to have once encountered such a case, and the impression was such as to make me determine that henceforth I would control my patient by safe and uninterrupted anæsthesia. Junker's inhaler is not equal to such emergencies, because, unless the bulb is pressed very gently, the liquid anæsthetic is forced into the pharynx. I therefore devised an apparatus to that end, reducing the pain, the bleeding, the shock, and the duration of the operation to a minimum.

"The apparatus was called the *Anæsthetizer* or *Anæsthetic Injector.* Its feature was that neither the inlet-tube nor the outlet-tube dipped into the liquid, so that it was impossible for any liquid anæsthetic to be injected into the patient's pharynx. But its drawback was that ether alone could not be used, because it was too freely diluted with air to have a thorough anæsthetic effect. Besides, the mixture of air and chloroform was also rather diluted, and, should a particularly refractory case present itself, there was no positive means of increasing the strength of the dilution at will and as necessity required. These inconveniences have been overcome in the new, improved apparatus. It is an injector, truly, and not an inhaler as we understand it.

"In this apparatus the inlet-tube dips into the liquid so that the air in passing out through the outlet-tube is much more charged with the vapors of the anæsthetic. But here at once with this dipping of the inlet-tube came two difficulties: first, upon releasing the compression on the bulb, the liquid was aspirated into the bulb; and, second, the liquid anæsthetic was thrown through the outlet-tube into the patient's pharynx. It required the utmost care and gentleness to avoid these accidents, and there were cases in which the full power of the apparatus had to be brought to bear to maintain the patient uninterruptedly anæsthetized."

These difficulties have been conquered, and they have been by placing a proper valve on the course of the inlet-tube, and by maintaining a certain distance between the level of the liquid in the bottle and the point of exit of the fixed brass portion of the outlet-tube. The distance must not be more than one-half of the height of the receptacle. It took much experimenting and close observation before this was found out. Diaphragms, perforated tubes, etc., were used, but in vain, as they all failed when the liquid exceeded a certain amount. Now, a certain quantity is necessary, otherwise it would compel a too frequent replenishing. Of course, the size of the rubber bulb is an important factor; if too small, it would not inject a sufficient amount of the anæsthetic; if too large, it produced such a splashing in the bottle as to require but a small amount of liquid; otherwise, if too much, the liquid would be injected into the pharynx.

The bulb is $7\frac{1}{2}$ inches in circumference at its middle. The size of the bottle is also to be considered; it is $6\frac{1}{4}$ inches in circumference or $1\frac{6}{8}$ inches in diameter. Therefore, the size of the bottle and of the bulb, the amount of liquid in the bottle, together with the distance of the surface of the liquid from the brass and fixed orifice of the outlet-tube, are the correlative factors.

Description of Apparatus.—The present improved apparatus is considered perfect in all particulars. It is composed of a glass cylindric receptacle, with a frame supporting a ring for the thumb and a rubber bulb, so that it can be worked with one hand. From the bulb originates a rubber tube, wrapped with coiled wire to prevent it from bending; it ends in the inlet-tube; just at the point of junction is a ball-valve, which prevents the liquid from entering the bulb when the pressure upon the latter is released. The inlet-tube extends through the liquid anæsthetic to the very bottom; its lower end is bevelled to prevent the orifice from being stopped by coming in contact with the bottom of the receptacle.

This inlet-tube slides up and down through another shorter tube, so that it can be drawn well up above the level of the liquid anæsthetic, thereby diminishing the strength of the

vapors injected through the outlet-tube into the pharynx. This feature makes the apparatus thus set an anæsthetizer of the first model.

There is a circular line on the receptacle showing how much, and no more, liquid anæsthetic should be poured in without running the risk of injecting liquid through the outlet-tube. This line corresponds to the middle of the receptacle from the bottom to the upper surface of the lid. This quantity will suffice to keep a patient anæsthetized for nearly two hours with chloroform alone, one hour and a half with a mixture of equal parts of chloroform and ether, and about an hour with ether alone. The receptacle is closed by a metallic lid that screws around its neck; a washer makes it air-tight.

From this lid springs the metallic portion of the outlet-tube; it originates directly from the under surface of the lid; it is $\frac{1}{2}$ inch in diameter inside and $1\frac{1}{2}$ inches in height; after a *very sharp* curve of 90° it terminates by an orifice of not less than $\frac{3}{16}$ inch. Repeated experiments have determined these dimensions; any decrease in them increases the chances of sputtering and of injecting liquid into the throat.

To this metallic portion is attached a rubber tube 30 inches long, so that the anæsthetist can hold himself well out of the way of the operator, leaving more room and play for those directly concerned in the operation. This tube should be sufficiently rigid not to bend too easily; its interior diameter should be $\frac{3}{16}$ inch. Its last eight inches are formed by an ordinary rubber catheter, No. 13 English, connected to the main tube by a piece of glass or metallic tubing; this nasal segment can be changed to a smaller one when operating upon children. It is provided with a clasp, seven inches from the extremity; this clasps the nostrils and holds the tube in proper position. The receptacle is readily emptied through the outlet-tube after the operation is over.

The lid is provided with a funnel, through which the anæsthetic is poured into the receptacle, and through which it can also be emptied after being used. To the edge of the funnel is adapted a clasp with a long arm, that answers for a hook by which the apparatus can be suspended from a buttonhole; the

clasp is to catch on to the cloth of the gown when there is no button-hole for the hook. Thus the anæsthetist may have both hands free, resting or helping for a while.

Modus Operandi.—When the apparatus is to be used it is first filled with the anæsthetic up to the circular line; that represents $2\frac{1}{2}$ ounces. The nasal end of the tube is smeared with vaselin. If desirable, an aseptic thin towel in a single thickness can be thrown over the apparatus without interfering with the proper working.

After the patient has been thoroughly anæsthetized by any of the ordinary methods, the face-piece is removed, the tube is introduced through the nose until the clasp is reached, a distance of 7 inches, and the clasp is made to grasp the nostril and fix the tube; the end of the tube is then in the *lower pharynx;* that is necessary, because, if too high up, the patient, breathing through the mouth, would not inhale a sufficient amount of the anæsthetic.

The anæsthetist places himself to one side or other of the middle of the patient, so as to feel the radial pulse, observe the respiration, and be well out of the way of the operator and his assistants. By compressing the bulb the apparatus is set to work. It injects *only the vapor*, and no liquid anæsthetic into the pharynx, *regardless of the force used on the bulb.* The bulb, however, should be compressed gradually, not jerkingly, specially if it causes coughing or recoil of the patient. By compressing the bulb more or less quickly and thoroughly the amount of anæsthetic is graduated. As much as possible the compression should take place at the time of each inspiration. This rule compels a closer watch on the respiration.

It takes very little anæsthetic to maintain anæsthesia when a patient has already been well anæsthetized. It is important not to keep on compressing the bulb if the patient does not require it, or if the stage or procedure of the operation is not painful. Much harm is often produced by all methods by unnecessarily prolonged *deep* anæsthesia, which harm is often passed under the name of shock, exhaustion, etc.

At times, when the patient expires, a resistance is felt upon pressing the bulb; of course, all force on the bulb should be

suspended until it is felt that the resistance has yielded and the patient is about to inspire.

Anæsthesia with Chloroform Alone.—When chloroform alone is used the effects are, at their best, quick and thorough. Greater care should be exercised when chloroform is used alone. It is then that it would perhaps be prudent to draw the inlet-tube up above the level of the liquid; the dilution is then diminished.

Mixture of Chloroform and Ether.—The mixture of equal parts of chloroform and ether is the one I prefer. It has the advantage of the quick and thorough effects of chloroform and the stimulating action of the ether.

Anæsthesia with Ether Alone.—The use of ether alone in the apparatus at first excites the throat if the patient has been chloroformed, but this soon passes off, and anæsthesia is well maintained throughout the operation. Of course, those patients who yield with difficulty to the ordinary method of anæsthetization will be more troublesome with ether. It requires more ether, more complete and frequent compressions of the bulb, and a closer observation of the inspirations than when chloroform alone is used. We should remember, however, that ether, especially if used alone, is contraindicated in operations about the face, head and neck, because of the great congestion which it usually produces.

Proportions of Anæsthetic Vapor and Air.—Mr. Hermann Fleck, Ph.D., Instructor of Chemistry in the Harrison Chemical Laboratory of the University of Pennsylvania, was kind enough to determine the proportions of anæsthetic vapors and air at each compression of the bulb. When the tube is above the level of the *chloroform* the expelled air contains 8.2 per cent. of vapor; when the tube extends through the chloroform, the expelled air contains 11.9 per cent. of vapor, or about one-third more. When the tube is above the level of the *ether*, the expelled air contains 18 per cent. of vapor; when the tube extends through the ether the expelled air contains 37.2 per cent., or double the quantity. It is noticeable that the expelled air is much more charged, about three times more, by passing through ether than when passing through chloroform, and only

about twice when the tube does not extend into the anæsthetic. In all cases, of course, the dilution, after it passes from the outlet tube and is inhaled, is from four to six times weaker.

SUNDRY REMARKS.—The amount of anæsthetic consumed is very small, about 1 ounce of chloroform per hour, but 2½ ounces of ether for the same length of time. There is no external evaporation, and this will be greatly appreciated by the operator and his assistants.

The apparatus works very well also when the head is lowered, as in the Rose position.

Should the operation involve the two nasal cavities at the same time when the tube might be in the way, the tube could be introduced through the mouth into the lower pharynx, care being taken to prevent the tube being bitten by using a wedge or gag, or by connecting the end with a metallic tube, or, best, with a disinfected male metallic catheter, which the teeth could not crush.

The end of the flexible tube may be connected with the apex of the face-piece or cone placed over the mouth and nose and the vapor of the anæsthetic forced into it. But the face-piece must fit tightly and exclude the air, because the air from the bulb has already diluted the chloroform. For that reason ether used thus very seldom produces anæsthesia.

Anæsthesia may be produced from the outset without previously using a face-piece by introducing the tube at once through the nose into the lower pharynx. This does away with all possible nasal reflexes, the effects of which have been so graphically demonstrated by Professor Laborde, the successor of Claude Bernard and Paul Bert at the College de France, in Paris.

The lower end of the bulb is so arranged as to allow it to be connected with a piece of tubing leading to a bag of oxygen, if desired.

For obvious reasons it is important that all connections should be air tight.

Care should be taken that no bends or kinks form in any part of the tubes, or this will interfere with the proper working of the apparatus.

Sometimes the little ball-valve in the tube becomes adherent to the margin of the orifice inside and the bulb does not empty; by striking on the tube at that point the valve becomes loose again.

The bulb is detachable and may be removed whenever this becomes necessary, that is, when it loses its firmness and elasticity, and when the valves get out of order. This is determined by pressing tightly the tube of the bulb, and compressing the bulb; if the air is then expelled it is because the valves are out of order. The manufacturer can supply a new bulb by mail.

Every part of the apparatus can be taken apart to be thoroughly cleaned and sterilized.

The apparatus is most useful also in operations about the head and neck, allowing the operator and his assistants more room, and sparing to all around the unpleasant odor of the anæsthetic.

The device has been used in the Charity Hospital of New Orleans by about all the surgeons, Drs. Matas, Delaup, Martin, Bloch, etc., also by Dr. De Roaldes in the Sanitarium. I have used it for Dr. Lange, in New York, in the presence of Drs. Halsted and Fenger, and in the Jefferson Clinic, in Philadelphia, for Drs. Keen and Hearn, in the presence of Drs. Da Costa and Barton. All these surgeons expressed themselves well pleased with the results.

No ill effects have ever resulted from the direct contact of the vapors of the anæsthetic with the mucous membrane of the pharynx or larynx.

CONCLUSIONS.—This apparatus is the *only one* with which there is *no risk of injecting liquid anæsthetic in the pharynx regardless of the force applied to the bulb.* Its safety, simplicity, compactness, portability, efficiency and easy management speak for themselves.

Its use results in a great saving of time, pain, bleeding and shock to the patient, thereby contributing materially to the saving of life in operations which, for the most part, are long and bloody, and often bring the patient to death's door. It also provides a great saving of mental strain to the surgeon,

who can proceed rapidly and uninterruptedly with the operation.

Abstract of a Letter from Dr. Marion Souchon, Son of the Inventor.

"NEW ORLEANS, July 20, 1896.

"Concerning the use of the instrument in regard to after-effects, I have witnessed its use more than a dozen times, followed the cases, and failed to see any incidental complications. As stated in brief, the apparatus has been used by all the surgeons here; also by Dr. DeRoaldes, Chief Surgeon of the Eye, Ear, Nose and Throat Hospital.

"I could not say whether the doctor has any data relative to experiments asked, and I regret it, for I feel confident of its favorable comparison with other such devices."

On Tissue Changes Found in Cases of Secondary Death After Ether.

In a series of carefully-conducted experiments by Prof. H. C. Wood and Dr. William S. Carter, chiefly on dogs, and a post-mortem of an adult female who was supposed to have died from the effects of ether, after the removal of an ovary containing a papillomatous cyst, about ten fluid ounces of ether were used. Consciousness was regained in the ordinary length of time; there was no pain, but the patient complained, when spoken to, of "feeling so tired and weak." The urine was examined before the operation and was found normal in specific gravity and free from albumin. There was, however, a family history of tuberculosis—all the members of which were dead, except herself.

We have not space for a full detail, but state that the protoplasm was found turbid and granular. In the muscle of the diaphragm the fibrous layer had lost their striation, and had a granular appearance with pigmenting infiltration distributed irregularly through the protoplasm, which is unquestionably granules of fat.

Kidneys.—There was an excess of connecting tissue. Several

of the glomeruli show hyaline degeneration in the tufts of capillaries and the capsule of Bowman.

To sum up, the condition found microscopically was brown atrophy, with cloudy swelling of heart; cloudy swelling and fatty degeneration of kidneys, which showed some chronic disintegrated changes, fatty degeneration and brown atrophy of muscle of diaphragm.

The following were a few of the conclusions:

That chloroform always produces a much more profound disturbance of metabolism, which is more apt to cause death than ether.

That although the tissue changes found in cases of secondary death after ether or chloroform are alike in character, and may be about equal in intensity when the two agents are given in poisonous doses for the same length of time, on one or upon successive days, and not followed by death, the tissue changes caused by chloroform are much more serious than those produced by ether.

In dogs, invariably, the straight tubules of the kidneys were most affected. Cloudy swelling; disappearance of muscle; striated granular degeneration; the occasional appearance of hyaline and of fatty degeneration.

These valuable experiments will require confirmation more especially in cases in which the individual's family had not suffered from hereditary disease.

Is It Possible to Have Death Produced by an Anæsthetic Some Time After the Cessation of the Administration and the Return of Consciousness?

The following are the conclusions of Drs. Wood and Carter:*

The conclusions which have been reached by the series of experiments recorded in the present memoir are:

First.—That lowered arterial pressure has a comparatively feeble effect upon the respiration and upon the vaso-motor sys-

* From an original essay in manuscript kindly loaned to the author by Dr. H. C. Wood.

tem, and that that effect is distinctly stimulating rather than depressing, unless, indeed, the imperfect supply of blood to the respiratory and vaso-motor centres be continued so long as to impair their nutrition.

Second.—The circulation recovers itself more slowly after profound etherization than after a like chloroform narcosis.

Third.—That it is possible for an anæsthetic to produce death some hours after the cessation of its administration at a time when the cerebrum has long freed itself from distinct evidences of the narcotic, so that consciousness and intellectual action have been restored.

Fourth.—That prolonged etherization, as well as prolonged chloroformization, produce serious structural changes in various organs of the body; that this occurs in the lower animals and in man; a comparison of our results upon dogs and the lesions found in the body of man (B).

Case of Miss B. shows a uniformity of change, unless it be in the fact that in the dogs invariably the straight tubules of the kidney were more affected than were the convoluted tubules; whereas, in the case of Miss B. the convoluted tubules were more affected than the straight tubules. Cloudy swelling, disappearance of muscle-striæ, granular degeneration, the occasional appearance of hyaline change and of fatty degeneration, were, however, the marked features in all the cases.

Fifth.—That in many cases the amount of tissue change found after a secondary death from ether or chloroform does not seem to be sufficient to have produced the death by simple arrest of the functions of the organs, although it is impossible to decide accurately how far the partial failure of function of many vital organs may work together to bring about the fatal result. It is possible that in the disturbance of nutrition, secondary poisoning may be produced which may have deleterious effects upon the general nervous system. At present, however, the only established facts are the administration of the anæsthetic: nutritive changes produced by that anæsthetic, ending in distinct structural alteration and death. It cannot, at this time, be determined whether the death is attributable to the alteration of structure, or whether it is due to some secondary

poisoning; the matter is not, however, of practical import, the ether or the chloroform under any circumstances being the cause of death.

Sixth.—That in cases of secondary death, after ether and chloroform, the structural changes are similar in character and may be equal in intensity; but after narcosis of a certain duration—say one hour—from ether, the changes in the tissue are not nearly so great as will be found after a narcosis of the same duration, one hour, produced by chloroform; and that therefore chloroform is much the more active agent in the production of structural lesions—a conclusion which is confirmed by the fact, which has been very apparent in our researches, namely, that secondary deaths in animals occur very much more frequently after chloroform than after ether.

In applying these conclusions to the subject of practical anæsthesia, it is evident that, contrary to what seem to be *à priori* probable, the depression of the circulation produced by chloroform has little or no direct effect upon the respiratory centres; and that the failure of respiration, which occurs during chloroformization, must be solely due to the direct influence exercised by the drug upon the respiratory centres. Failure of respiration, undoubtedly, profoundly affects the heart, but the relation between the two functions does not seem to be reciprocal; so that the fact that ether stimulates the circulation does not, so far as the respiratory centres are concerned, give it any superiority over chloroform.

Clinical experience shows that nausea and general depression are more pronounced after the use of ether than after the use of chloroform, a difference which is strongly insisted upon by the advocates of chloroform as an important agent in favor of that anæsthetic. Our research confirms clinical observation, and experimentally shows that the depression of the circulation produced by ether is more permanent than that caused by chloroform, the reason probably being the large amount of ether which is necessary to produce profound narcosis with lowering of the arterial pressure, an amount so large that it can neither be burned up in the system nor yet eliminated in the time which would be necessary for the much smaller amount of chloroform to be gotten rid of after chloroformization.

An important result of our labors is the demonstration of the fact that anæsthetics may produce death in the animal, and, therefore, certainly in man, at a time when the ordinary effects of the anæsthetic have disappeared, and that in the bodies of human beings and animals widespread structural lesions are to be found. It would seem from our experiments, in conjunction with those previously performed with chloroform by other observers, that during ether and chloroform narcosis there is always interference with the nutrition of the protoplasm throughout the body. Ordinarily this interference is not sufficient to produce permanent structural lesions; the cloudy swelling subsiding, the protoplasm regains its normal condition. The fact of the change is, however, very important, as indicating that anæsthetics produce much more effect than is usually supposed, and the incautious use of them for every trivial operation is not praiseworthy. Local anæsthesia certainly should be used by the surgeon whenever it is applicable.

The question as to the effect of previous health upon the effect of anæsthetics on the general tissues is most important. At present we have no way of deciding in any case whether the tissues of the individual will or will not resist the nutritional changes of ether or of chloroform. Certainly, however, there are great differences in different individuals. In the animal a previous narcosis notably weakens the resistive power of the tissues. It is a matter of great interest that Miss B. came of a family the members of which were all dead, except herself, of tuberculosis. The essential heredity of such a family is lack of vital resistance to the tubercular bacillus, and it is possible that there is also a lack of vital resistance to various morbific agents. The slight brown atrophy of the heart, and the slight cirrhosis of the kidney, neither of which had ever manifested itself at all during life, may possibly have also impaired the general tissue resistance.

Our researches throw light upon the question which must forcibly present itself continually to every practical surgeon: Which is the safer anæsthetic for prolonged use? It is true that the condition of depression lasts longer after ether, and that therefore chloroform would seem preferable; but on the other hand we demonstrated that chloroform is much more active in

producing structural change than is ether, and that the dangers of what we call "secondary death" are greater after chloroform than after ether.

It is now generally acknowledged that the danger of sudden death during the period of anæsthetic unconsciousness is much greater from chloroform than from ether. We believe that we have proven that the after dangers from chloroform are much greater than from ether, and that in the question of immediate result when it is desired to produce prolonged anæsthesia, ether should always be preferred to chloroform.

Ether by the Rectum.

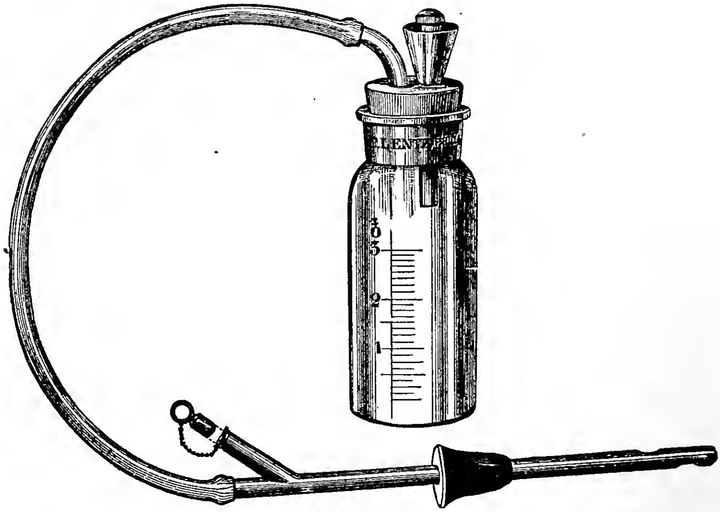
The advantages which are still claimed for ether by the rectum are as follows: It avoids the first and chief danger to the respiration, the production of stertor, and the falling back of the jaw and tongue. Second danger. It avoids the irritating influence of ether upon the mucous membrane of the throat and air-passages, first shown by croupy respiration and flow of frothy mucus. Third. It prevents a dangerous complication, tetanic setting of the inspiratory muscles of the chest; no air enters; respiration with the diaphragm fails to fill the lungs, and the patient dies, as in true tetanus. Fourth. It prevents simple exhaustion, another source of danger, as the patient can take nourishment, before the operation, to sustain the system. Death is not so apt to occur from slowly-failing respiration when the ether is employed by the rectum. Fifth. It avoids the distressing and exhausting vomiting and lasting nausea which is so disastrous in abdominal section, in operations for hernia, and sections of the cornea and iris.

The Chief Danger from the Administration of Ether per Rectum.

The chief danger from the administration of ether per rectum has been found, as has been shown in the report of cases, first, the overdistension of the bowels with the ether vapor, or the tenesmus, with bloody discharges from the rectum, caused by fluid ether being forced through the tube and deposited in con-

tact with the mucous membrane, producing freezing of the parts and secondary inflammation and ulceration. Experiments have demonstrated that the cool rubber tubing which has been employed had a tendency, unless kept warm by wrapping with cotton or felt, to produce a rapid condensation of the vapor driven over into the ether, which boils by the simple heat of the hand, or 93° or 96° F. The temperature of the water-bath should not exceed 103° or 105° F. If the temperature is allowed

PLATE 44.



C. LENTZ. Phila.

to rise to 120° or 130° F., the boiling becomes so active as to drive over fluid ether.

In a few rare operations the vapor of ether per rectum may be employed with advantage, as in cases of excision of the superior maxilla. It has been found that the administration of the ether by the rectum in operations on the superior maxilla was satisfactory. The patient becomes profoundly anæsthetized, and the anæsthesia is continued for some time. The patient comes out from under the influence of ether with less subsequent annoyance than usually follows the administration of this anæsthetic. Dr. L. A. Stimson devised an instrument for this oper-

ation, consisting of a tube about the size of a No. 40 urethral catheter, surrounded at one end with a large sponge with a rubber coating, which, when passed into the pharynx, prevents the flow of blood in that direction while the patient breathes through the tube.

In abdominal surgery, or if there be marked intestinal lesion, this mode is contraindicated.

Its inapplicability in cases of accident and emergency, when time cannot be allowed to prepare the bowel, has already been mentioned.

Other points of advantage and disadvantage may occur in later experience, and to other observers, and new dangers may be discovered; but we are convinced that this method is worthy of further trial, and will find its place in surgery, fulfilling its own, though not *all*, indications. Like all else in therapeutics, it must pass through the stages of bungling use, condemnation and revival.

Dr. Miller's form of apparatus, see Plate 44, which was made for this purpose, consists simply of a water-bath, a graduated bottle provided with a funnel and valve for pouring in the ether, and a supply-pipe for conducting vapor to the rectum. This tube terminated in a straight recurrent catheter, the exhaust channel of which is controlled by a valve. The catheter is furthermore provided with a movable collar for pressure against the anus, it having been found that the vapor tends to escape by the tube.

Internal Administration of Ether.

Exhibited internally, ether is an excellent diffusible stimulant. It sinks in water, and is best administered mixed with spermaceti and sugar, or in mucilage of gum arabic; its taste is hot, pungent and irritating, and when placed in the mouth, ears, nose or rectum pain is produced. It dissolves in alcohol, whiskey or brandy; and when required as a powerful stimulant, as in fainting, exhaustion or collapse, this is an excellent method for administering it. In using it for some time, it is best given enclosed in capsules.

Gout.—In sudden attacks of gout in the stomach or intestines a useful mixture is the following:

℞ Spiritus vini gallici,
Ether, ... āā . . . f℥j. M.

Sig.—Dose, one teaspoonful in sugar and ice water, repeated until relief is afforded.

This same preparation will be found valuable in *spasm of the stomach, or intestines, or heart.* Ether has been proved useful in *tape-worm*, alone, or combined with the oleo-resin of the male fern. The patient must live upon milk and a little bread for one day, and the following morning, fasting, take the full dose:

℞ Oleo resinæ filicis, ... ʒss.
Ether, ... f℥j.
Mucilag. acaciæ, ad. ft., ... f℥ss. M.

This is to be repeated in three hours; in the evening food can be taken, to be followed with a full dose of castor oil with twenty drops of spirits of turpentine. Some French authorities prefer to give fʒiss. of ether alone, administered at once, and followed in two hours by the purgative.

Ether is also one of our most potent remedies in *hysteria*, especially when associated with valerian, asafœtida, musk or camphor. In the first with the fluid extracts, as follows:

℞ Ether,
Valerian. ex. fluid, . . āā . . f℥j. M.

Sig.—A teaspoonful every hour.

In the second it is mixed with the tinctures as follows:

℞ Ether,
Tinct. Asafœtidæ, . . . āā . . ℥j.
Mucilag. acaciæ, ... ℥j. M.

Sig.—A teaspoonful every hour until relieved.

With musk:

℞ Moschus,	. . . .	℈ij.	
Ether,			
Mucilag. acaciæ,	. . āā . .	f℥j.	M.

Sig.—A teaspoonful every hour.

With camphor, ether is not only useful in hysteria, but all forms of "*nervousness*," in *dysmenorrhœa*, *diarrhœa*, *cholera*, *abnormal sexual excitement*, *epilepsy*, *hysterical*, *puerperal and strychnic convulsions.* Camphor with ether is best administered as follows:

℞ Vitelli ovi,	. . . .	℥ij.	
Pulv. camphoræ,	. . . . . .	ʒij.	
Ether,	. . . .	℥ij.	M.

Add the ether to the camphor, and then the emulsion; administer in tablespoonful doses every two hours.

Treatment of Sciatica by Subcutaneous Injection of Ether.

Fifteen drops was first given, which was followed immediately by great relief from the pain, and soon passed off. The injection, in increasing doses up to thirty drops, was repeated morning and evening for three days, when the patient was discharged cured. No local injury resulted; the injections were made in the ordinary superficial method, and not deep.

Asthma.

Inhalation of ether is very valuable in relieving spasmodic asthma, and obtaining sleep for the patient. It can be employed alone, or associated with the tincture of digitalis, conium or opium. The ordinary dose of the ether is from ten to forty minims, and of the tincture of digitalis or opium from ten to thirty minims.

The Ether-Spray in Post-partum Hæmorrhage.

The use of ether-spray in post-partum hæmorrhage has been sometimes successful in cases in which the usual means of

arresting the flow had been resorted to without effect. The spray is directed on the abdominal walls, along the spine and over the genitals.

Coryza and Obstinate Hoarseness.

Drs. Chapman and Physick recommended the vapor of equal parts of Hoffman's anodyne or compound spirits of sulphuric ether, with equal parts of laudanum, in cases of recent catarrh, in coryza and obstinate hoarseness, by inhalation.*

Ether as an Expectorant.

Ether has been found useful as an expectorant in the subacute or chronic form of bronchitis. It is a valuable remedy, and is prescribed in five and ten-minim doses, on a little sugar, every three or four hours, or it can be taken by inhalation, as follows: The cork of a bottle, half-filled with ether, is perforated by two glass tubes, neither being immersed in the ether. A few inspirations through the tubes every hour or two is sufficient. As the remedy is also a diuretic and diaphoretic, its utility is thereby increased.

Chorea.

A jet or hand spray of sulphuric ether, free from alcohol, applied to the spine will relieve the most violent spasmodic or convulsive attack of chorea, with the subsequent use of Fowler's solution, five to ten drops three times a day in water, and occasional application of the galvanic current to the spine.

Nervous Aphonia, or Temporary Loss of Voice.

The vapor of ether is a most valuable remedy in hysterical or nervous loss of voice. It has been the means of discovering malignerers, who were supposed to be deaf and dumb, and who, as soon as they came under its anæsthetic influence, were able both to hear and speak.

* We have also employed one-quarter grain of sulphate of morphia in the place of the laudanum, making a more elegant preparation, and with good success.

Diphtheritic Angina, or Pseudo-Membranous Croup.

Cases of diphtheritic angina have been treated with success by inhalations of ether and steam, with the internal use of brandy, calomel, etc.

Whooping-Cough.

Ether alone by inhalation is extremely useful in the relief of whooping-cough ; and a combination of ether sixty parts, chloroform thirty parts, and oil of turpentine or tar one part, has been found a successful remedy. The patient should be confined to his room, and at every access of coughing use a portion in an inhaler.

Ether Intoxication.

A few years ago there was published* "The Confessions of an Ether Inhaler," a member of our own profession, for whom it subsequently became necessary to sign a certificate of insanity.

Dr. Ewald, of Berlin, reports a somewhat similar case. It is that of a man aged thirty-two, who was admitted into the Charité Hospital, under Professor Frerich, suffering from general debility and trembling of the muscles. On inquiry, it was found that he was notorious in Berlin for intoxicating himself with ether, his abuse of which had reduced him to his present miserable condition. He was originally temperate, and had been a university student, passing all his examinations with credit ; he was, however, of a mystical turn of mind. Unfortunately, a little more than nine years ago, there fell into his hands a medico-popular treatise, in which the use and effects of ether, used medicinally, were described, and a glowing account was given of its effect in quickening the creative power of the mind. He procured about two or two and a half ounces of sulphuric ether, and inhaled it from a handkerchief ; the result being to produce insensibility for about a quarter of an hour, during which time he imagined that he lived for an indefinite time, and travelled over whole worlds. This condition, however, he was not again able to induce in so high a degree. Becoming grad-

* Medical and Surgical Reporter.

ually more and more addicted to his habit, he no longer confined himself to indulging himself in his own room, but with his etherized handkerchief before his face, he wandered through the streets, purchasing small quantities of ether at the druggists' shops, until, at last, he became so great a nuisance to them that many of them closed their doors against him. He was also turned out of his lodgings, on account of the annoyance produced by the smell of his breath, and became a houseless wanderer, reduced in means and in health. In the hospital there was no indication that his mind was affected ; his memory was not impaired ; his style of speaking was fluent. On one occasion an attempt was made to produce complete anæsthesia. For this purpose more than seven ounces were required ; the ether being given by an inhaler, and loss being prevented by closing in the apparatus with cotton-wood. No sooner, however, was the inhalation stopped, than the state of insensibility passed off. He was then allowed to take the ether in his own way, by inhaling it from a handkerchief. Given in this way, it produced a stage of excitement, during which he danced about the room, talked nonsense, and appeared much pleased, but there was no true narcotism. It was not thought justifiable to subject him to other experiments with ether, as it was desirable to break through his habit. It is interesting that his susceptibility to the action of cannabis indica was not impaired. This drug was given as a substitute for ether, and on the first occasion, too large a dose having been given, the result was the production of phantasms, such as are induced by the smoking of hasheesh.

The late Dr. Morgan, of Dublin, states that ether is employed in certain portions of Ireland as a substitute for whiskey.*

A case has come under the writer's notice in which a patient began the use of sulphuric ether in teaspoonful doses as a nervine ordered by a physician, and ultimately increased the dose to one pint per day. When informed of its injurious character, she had lost her appetite, and suffered gastric disturbance ; she

* In Ireland and Russia a law has been recently passed forbidding the public sale of ether unless ordered by a regular physician.

gradually diminished the quantity, and was able to give it up after a month or two. The only effect it had upon her was to give her apparent strength to go on with her teaching of music. Large quantities of ether have been taken internally, and, so far as we have been able to learn, no death has yet occurred from its use in this way.

Chronic Intoxication from Ether.*—The patient, a woman of 48 years, had been in the habit of swallowing after each meal a lump of sugar wetted with sulphuric ether to relieve a difficulty in digestion. During the space of two months and a half preceding her admission to the hospital *de La Pitié*, she took, in this manner, a total of 180 grammes (nearly six ounces). When she had continued the practice for about seven weeks, trembling of the hands commenced. A week later she began to feel severe pains in the lower front part of the chest, and between the shoulder blades. She also suffered from vomiting of a whitish watery fluid on rising in the morning. In a week more her gait became unsteady, and she suffered from trembling of the toes, cramps in the calves, and prickling sensations in the feet.

Upon admission to the hospital she presented all the above symptoms. The pain resembled that which would be caused by two blisters of eight or ten centimetres in diameter, the one placed a little above the epigastrium, the other at the same level on the back. It was intermittent, and was excited by any sort of ailment. There were regular slight twitchings in certain portions of the limbs. The strength of the hands was not diminished. Almost continual buzzing in the ears; muscæ volitantes occasionally, usually followed by a brief attack of frontal headache. Pupils slightly enlarged. Sleep undisturbed. No fever. Soft souffle at base of heart and in vessels of neck, accompanying the first sound. No other important symptoms.

An emetic at entrance, a daily bath, a little opium at night, and abstinence from ether, constituted the entire treatment. Recovery was complete at the end of two weeks.

* Martin. *Gazette des Hôpitaux*, May 10, 1870.

Vivisections.

An excellent use of ether may be made in regard to animal vivisections. Ether enables us to lull the sensibilities of the victim, tranquilly pursue the natural workings of the internal organs, and the changes which take place from experimental applications; while the student of surgery can accustom himself to those gushes of the vital fluid, which, in the human body, are viewed with so much terror by the unpracticed. Animals of any size may be etherized in a box, or by covering the head with an India-rubber sack, into which a mixture of ether and atmospheric air is forced.

Vivisections with Ether and Chloroform.

Prof. Schiff, of Geneva, states: "In our experiments, that is, in more than three thousand cases, we have adopted etherization with a view to preserve the life of animals; and that, with few exceptions, indicated elsewhere (Memoir on the Laryngeal Nerve), not a single case of death occurred. On the other hand, chloroform has cost us a considerable number of animals when I have wished to push anæsthesia to its ultimate stage."

In our experiments we have proven that even bromide of ethyl is safer in making vivisections than chloroform.

CHAPTER VI.

Ethers which have Anæsthetic Properties—Acetic Ether—Experiments by Dr. H. C. Wood on Animals, etc.—Formic Ether—Hydriodic Ether—Properties and Objections to its Use—Mythlic Ether—Dr. Richardson's Experiments with It—Bichloride of Methylene—Observations upon It by Dr. Buxton and Spencer Wells, of London—Ethyl Iodide—Ethylene Bromide—Iodoform—Carbon Dichloride—Bromoform—Tetrachloride of Carbon—Butyl Chloride—Chloride and Bichloride of Ethylene—Iodide of Methyl—Amylene—Chloral Hydrate—Acetic Aldehyde.

Acetic Ether ($C_2H_6C_2H_3O_2$).

Acetic ether is colorless, and has an agreeable odor and burning taste. Specific gravity, 0.89; boiling-point, 165.2° F. If

kept in contact with air, and in the presence of water, free acetic acid is formed. According to Dr. H. C. Wood, in pigeons and rabbits it produces perfect unconsciousness without as much previous struggling as when sulphuric ether is used, and has the advantage over that compound of being less inflammable; on the other hand, its volatility is less. In experimenting with this ether we must use caution.

Formic Ether ($C_2H_5CHO_2$).

Formic ether is a colorless liquid, recalling the odor of rum, and having an agreeable taste. Specific gravity, 0.915; density, 62.8; boiling-point, 127.3° F. It dissolves in nine parts of water, and all proportions in alcohol, ether, fixed and volatile oils. It has been found that this ether decomposed into alcohol and alkaline forminates by the alkalies of the blood. When inhaled, it lowers the temperature and induces asphyxia.

Hydriodic Ether (C_2H_4I).

Hydriodic ether is a colorless, non-inflammable liquid, having a peculiar etheral odor and taste, soluble in alcohol and nearly insoluble in water. It boils at 158.5° F.; specific gravity of liquid at 32°, 1.9755. Exposed to the air and light, it liberates iodine and becomes brown, which irritates the nostrils and causes lachrymation, and is sometimes employed by inhalation to bring the system under the influence of iodine in chronic bronchitis and phthisis.

Methylic Ether ($(CH_3)O_2$)—**Methyl or Bichloride, So called by Richardson.**

Mixture of 1 vol. methyl alcohol and 4 vols. chloroform.

Methylic ether is a colorless and very inflammable gas, heavier than air, of an oppressive odor. (In specific gravity, boiling-point, etc., we have followed Prof. William Allen Miller.) It is soluble in water, wood-spirit, alcohol and ether. A saturated solution in ether, at 32° F., has been recommended by Dr. B. W. Richardson, who experimented upon himself, and found that there was no preliminary spasm excited in the larynx, or

elsewhere. The pulse arose to 96, and the anæsthesia was perfect, yet he objected to it because it rapidly volatilizes from its solution and on account of its unpleasant odor. Dr. Carter says: "In Dr. Richardson's own hands I have seen the various (new) ethers act perfectly well, producing complete unconsciousness and relaxation of muscle without either struggling or sickness, and without unpleasant symptoms of any kind; but I cannot judge how far such results may have been due to the qualities of the agent employed, how far due to specially skilful or careful administration, or how far to the state of the patients themselves."

Bichloride of Methylene (CH_2Ol_2)—An Anæsthetic.

PREPARATION.—By acting on chloroform with nascent hydrogen.

$$CHCI_3 \times H_2 = CH_2CI_2 \times HCI.$$

Boiling-point, 40° C. (104° F.).

Methyl and Methylene are two terms which, with their affixes, are hopelessly confusing to the practitioner. Rival manufacturers, eager to obtain predominant recognition, so manipulate terms, that it is almost hopeless to get reliable clinical reports from the action of these various, but more or less similar, agents. A little explanation of each may not be out of place here. "Methyl blue" is an anodyne and anæsthetic, considerably employed with some success in the treatment of diphtheria—mixture of 2 parts and 98 parts sugar. "Methyl, dahlia or Paris violet" is pyoktanin plus, the new antiseptic.

CHARACTERS OF BICHLORIDE OF METHYLENE.—A colorless, volatile liquid with smell like chloroform.

ACTION.—Like that of chloroform, but more rapid, though a larger quantity is required. It depresses the action of the heart more than chloroform, and death is even more sudden and without warning symptoms.

This anæsthetic was carefully studied by Dr. Richardson, who gave it a very high character. This was in 1867. His views were soon called in question by Nusbaum in Germany, and Tourdes, Hept and Pēan in France, while Spencer Wells took

up the subject and defended it in England. For years it was fully tested at Moorfields Ophthalmic Hospital; but two deaths occurred without any indication of danger from the state of the pulse or heart. In 1876 we had it prepared by Dr. W. H. Greene, and even with all his care the specimen contained chloroform. It was then tested by us and the late Dr. Washington Atlee, the article having been obtained through Spencer Wells; but Atlee did not find it as satisfactory in ovariotomy as his mixture of ether and chloroform. Subsequently more deaths occurred from its use. Spencer Wells stated at the meeting of the British Medical Association, 1877: "Whatever may be its chemical composition, whether it is chloroform mixed with some spirit of ether, or whether it is really bichloride of methylene, I am still content with the effects of the liquid sold under that name."

Commercial methylene, obtained through agents accredited by Sir Spencer Wells, and therefore considered genuine, was a mechanical mixture composed of four parts of chloroform and one of methylic alcohol. In some comparative experiments they administered the two agents, finding that while the commercial agent behaved precisely like chloroform, the genuine methylene bichloride produced choreiform and epileptiform convulsions.

Mode of Preparation.—Bichloride of methylene is prepared by heating one part of methylic alcohol, two parts of common salt and three parts of sulphuric acid, and passing the gas through water into a glass globe, into which chlorine gas is conducted at the same time. The globe is drawn out below so as to form a thin tube, which passes into one tubulure of Wolf's bottle, the second tubulure being connected by means of a bent glass tube with a second Wolf's bottle, this second bottle being placed in ice; the other tubulure of this second bottle is connected with a flask cooled by means of a freezing mixture. The liquid which is condensed in the Wolf's bottles is chiefly chloroform, while that in the flask is almost pure methylene dichloride, or bichloride of methylene.

A mixture of chloroform and ether is sold as bichloride of methylene. On shaking this mixture with water, the chloroform is separated and sinks.

Dr. Dudley Buxton writes: "I believe I am accurate in saying Sir Spencer Wells obtains his methylene from only one source, and I am unaware that it is to be got elsewhere in England. The methylene so obtained was tested clinically, and found to produce the usual anæsthetic trance. It was then submitted to chemical analysis, and a result obtained which showed it to be composed of four parts methylated chloroform diluted by one part of methylic alcohol. Subsequently these investigators prepared some genuine bichloride of methylene ($C_2H_2CI_2$) which they administered to animals, with the result that no anæsthesia appeared, but in its place wild excitement, convulsions and death."

Ethylene Bromide. (Not Ethyl Bromide.) (Dibromethane.) ($C_2H_{42} = Br_2 — CH_2Br.r.$)

Lightly brownish liquid; chloroform odor; specific gravity, 2.189; 15° C.; misc. in all proportions. Boils 129–131.5° C. It must not be confounded with ethyl bromide, as it is a cardiac poison, anti-epileptic and powerful sedative.

USES.—It is employed in epilepsy, delirium tremens, nervous headache and nervous insomnia.

DOSE.—1–2 ♍ (0–06—0–12 Ce) ter a day in emulsion of gum arabic or almonds or in capsules. Caution—poisonous (Merck, in sealed tubes).

Ethylene Chlorhydrin.

(GLYCOL CHLORHYDRIN; MONO-CHLOR-ETHYL ALCOHOL.)

Ethylene chloride (not ethyl chloride); dichlor-ethane; Dutch liquid. $C_2H_4Ch_2 = CH_2ClCh_2Ch.C.$ Thin, oily liquid; pleasant odor; sweet taste; irritating vapor; specific gravity, 1.26 at 15° C.; soluble in alcohol, ether and chloroform; slightly soluble in water; boils 83.7°; anæsthetic, rubefacient; antispasmodic, anæsthethic in the place of chloroform; expectorant; useful in cramps, diarrhœa; externally, rheumatism and neuralgia.

Carbon Dichlorine or Chloric Ether

Has been used to a sufficient extent to indicate that it produces distinct cardiac depression.

Bromoform,

Which possesses undoubted anæsthetic properties, was found in experiments of Dr. Reichart, 1889–90, to powerfully depress the heart, and in one experiment on a small dog the intravenous injection of thirty minims of the preparation caused immediate cardiac arrest. Consequently, it was considered useless to pursue any further investigation in this line. This is also a dangerous impurity of bromide of ethyl.

It is employed in the treatment of whooping-cough, although "for several months the only treatment in our clinic for whooping-cough has been bromoform. The method of administration has been to prescribe one or two drachms pure, and give one to four drops in a teaspoonful of milk three to five times a day, according to age and severity of disease, and, moreover, to give special instructions that the *last remnant* be given from a spoon, as bromoform does not mix, but sinks to the bottom. A happy feature is its sweetness.

"Being entirely ignorant of its physiological effects, like all of us, I determined to 'try it on the dog first,' as some of us must. Feeling in perfect health, I took an initial dose of ten drops; no perceptible effects. In one hour, fifteen drops more; nothing experienced in regard to respiration, pulse or temperature, but slight swimming sensation in head. In another hour, another dose of fifteen drops; pulse slightly slowed, temperature and respiration normal, expectoration free and liquid. Very dizzy in head and somewhat nauseated, and general feeling of malaise, all of which was very transitory, so that in one hour I felt as well as before. The first sweet taste of the drug lasted but a very short time, giving way to a burning sensation of the tongue, which became very severe, such as capsicum produces. Food had no taste, and the throat reflex was entirely abolished, so much so that after twelve hours the index finger could explore the entire fauces without the least unpleasant sensation. I felt more of those structures digitally than I had thought possible, except under general anæsthesia."—Kreiger, *Tex. C.-Rec. Med.*

Care must be taken to see that it is in normal condition, that of a colorless liquid, for by exposure to the light bromine is set

free and colors the liquid. Foreign observers are most pronounced in its favor, and more practitioners in our own country should put investigations on record.

Bromol (tribromophenol) is not new, but has been known as the product of the action of bromine in excess on carbolic acid. As it has been found now to have marked antiseptic properties, this short name has been given it, both for convenience in use and to be in harmony with the already too many new compounds being pushed forth, most of which have names less indicative of their true composition. It has been applied with vaseline to open wounds with success. Its internal uses have been in cases of typhoid fever and cholera infantum. Little has been written yet on its therapeutic uses.

Butyl Chloride.

In the experiments of the British Committee it caused the cardiac pulsation to become weaker, and finally extinguished; while *methyl chloride* only effected drowsiness. *Isobutyl chloride* was not noticed as regarding any cardiac action.

Iodide of Methyl. (CH_3I.)

This compound was discovered by Dumas and Peligot in 1835, and is made by combining phosphorus, iodine and methylic alcohol. A safer and more agreeable preparation of it is made, according to Wanklyn, by mixing iodide of potassium and anhydrous methylic alcohol in a retort, in equivalent proportions; dry chlorine gas is passed into the mixture, which is then distilled, and the distillate agitated with water and rectified.

Iodide of methyl is a colorless liquid of an ethereal odor. Specific gravity, 2.199 at 32° F.; it boils at 110° F., and burns with difficulty, giving off violet vapors. This agent was proposed in 1868 by Dr. B. W. Richardson as an anæsthetic, but was found by him and by Prof. Simpson as unsafe. It has been recommended as a local anæsthetic in cancerous cases.

Amylene.

The vapor of this liquid was introduced by the late Dr. Snow as a substitute for the vapor of chloroform. It produces a loss

of sensibility without causing complete coma or stupor. Its use has already led to several deaths, and is not even as safe an agent as chloroform vapor for surgical purposes. The only appearance met with in one fatal case was an emphysematous state of the lungs, or an excessive dilatation of the air-cells, and in the other a distension of the right cavities of the heart, with dark fluid blood. There was no congestion of the brain, and no smell of amylene perceptible in the body.

Aldehyde. (C_2H_4O.) Ethaldehyde, Acetic or Ethylic Aldehyde.

Specific gravity, 0.801 (32° F.); boiling point, 22″ C. (71.6° F.); vapor density, 1.532.

Acetic aldehyde is a very volatile liquid, produced by the oxidation and destructive distillation of alcohol and other organic compounds. It is a transparent, colorless liquid, resembling the ethers, having a pungent, suffocating odor. It is very inflammable, and burns with a beautiful blue flame. It is mixed with water, and dissolves in alcohol and ether. It dissolves sulphur and phosphorus, also iodine, forming a brown solution, and becomes chemically changed by the contact or addition of an oxidizing agent which will reduce it to acetic acid. Aldehyde possesses anæsthetic power; small quantities of the vapor retard the pulse, large quantities accelerate the pulse and respiratory movements, while larger doses arrest them, causing irritation of the glottis and constriction of the chest, while the action of the heart is disturbed, with a tendency to entire arrest of respiration. It has therefore been classed as a dangerous anæsthetic. Three to five cubic centimetres (thirty-six to sixty grains) injected in watery mixture into the veins of a medium-sized dog produce almost immediate insensibility and arrest of respiration. Death is preceded by dilatation of the pupils.

Every alcohol can become an aldehyde by oxidation. The one referred to differs only in the following point: First, by the prefix par multiplying the chemical equivalent by four—$C_6H_{12}O_3$. Again, at the freezing-point it is, like oleic acid, a

solid. In its physical properties it is precisely the same as the one referred to. It is also, according to our experiments, an anæsthetic—forty-five minims, being inhaled on a towel, produced a choking, disagreeable sensation, with fulness of the head, but slight anæsthetic effect, and instead of accelerating the pulse it reduces it from 96 to 80. A second experiment was made with sixty minims, when there was considerable irritation of the nose and throat of a peppery character and no full anæsthesia, but the pulse rose to 114. The respiration was but slightly accelerated, and on recovery, which was rapid, there was no severe headache and no sick stomach or vomiting; there was, however, considerable irritation of the conjunctiva and slight dilatation of the pupil. The writer has tried it on himself and other patients, but with one exception it has been unsatisfactory. In a case of neuralgia of the fifth pair, cause exposure, it was given in forty-five minim doses, and the patient was relieved and slept all night, and did not find the taste so disagreeable when mixed with a wine-glass of sugar and water. A case of valvular lesion of the heart, the patient not being able to sleep unless under the influence of $\frac{1}{8}$ of a grain of morphia suppos. and $\frac{1}{150}$ of atropia, slept only two hours from 30 minims of paraldehyde. A second larger dose, 45 minims, had better results in the following mixture:

Paraldehydi, ...	ℳxxx.
Aquæ, ...	ad℥iss.
Syrupi aurantii, ...	ʒii.
Spts. chloroformi, ...	ℳxxx.

M. ft. haustus. Hora somni sumeod.

"Chloral Hydrate

Is an anæsthetic in a therapeutic sense, and has, like chloroform and ethyl bromide, given us painful instances of its acting at times altogether out of proportion to the dose. Fuller (*Lancet*, March, 1871) quotes a case where thirty grains caused death in a young lady. Schwaighofer (*Irish Hospital Gaz.*, 1873) reports another, of a drunkard, in which a drachm produced death; and three other cases (Reynolds, *Practitioner*,

March, 1870; Watam, *Med. and Surgical Reporter*, January, 1871, Fuller, *loc. cit.*), in which forty-five, eighty and thirty grains, respectively, caused alarming symptoms, and, from the large dose, death nearly ensued. Death has resulted from a dose of ten grains (*American Dispensatory*, 1880, p. 396). Other deaths have been reported (*Medical Times and Gaz.*, 1871, pp. 1831, 672; Norris, *Lancet*, 1871, i. p. 226, and Browne, *ibid.*, p. 574); and in some of these cases indisputable evidences of its power of weakening the heart were present. Did chloral hydrate become decomposed in the system into formic acid and chloroform (Personne, *Journ. de Pharm. et Chimie*, 1870, and Pellogio, *Schmidt's Jahrbücher*, bd. cli., p. 89; Liebreich, *Wiener Med. Wochensch.*, August, 1860), we could readily account for its acting at times in a manner wholly disproportionate to the dose, and for its being a cardiac depressant; but, as recent investigations disprove this theory (Hammertin, *Schmidt's Jahrbücher*, bd. cli.; Rajursky, *Ibid.*, bd. cli.; Amory, *N. Y. Med. Jour.*, 1870; Djurburg, *Schmidt's Jahr.*, bd. cli.; Leurison, *Archiv. Anat. u. Phys.*, 1870), we must look elsewhere for this toxic principle."

Chloral hydrate has been advised and employed in combination with, or given before, chloroform, but must be used with care, as it is a heart depressant.

On the Value of Oxygen Gas in Prolonged Operations in which Ether has been Administered as the Anæsthetic.

This gas is being found of greater value and more extended application every day. One of the most recent has been its use after prolonged operations in which extreme debility, asphyxia with cyanosis, and extreme nausea following the use of ether as the anæsthetic.

It is therefore with pleasure we present this practical paper of Dr. Hirsh, written at our request, in which he has given, in a very modest way, his experience of its value, and we feel sure, from his numerous operations with it, his views will be fully appreciated by the profession.

Oxygen to Antagonize Ether Anæsthesia, by A. B. Hirsh, M.D., Philadelphia.

"It is a curious fact that, of the countries most advanced in surgical science, Germany should find fewest advocates among her operators for that safest of general anæstheties, sulphuric ether. Among this small minority, however, is Prof. Landon, the eminent gynæcologist of Berlin, who, in the course of his extensive surgical experience, has found ample cause to prefer ether to chloroform or any mixture or substitute for these.

"In seeking an agent which would remove the unpleasant effects of ether, he discovered that, when the inhalation of this article was followed by that of oxygen gas, the object was attained, and in this way has done much to popularize its use in his own and other countries heretofore prejudiced against ether narcosis.

"Based on the publications of Landon, and on its use in the major operations occurring in the practice of his friends and self in Philadelphia,* the writer is prepared to urge the adoption of the Landon method for all cases in which a prolonged administration of ether may be necessary.

"Its very simplicity will do most to insure universal introduction, as, in obtaining the required articles for any operation, the surgeon simply orders in addition a steel cylinder containing from fifty to one hundred gallons of oxygen gas. Now, at the end of the operation, or if at any stage during its course symptoms of cyanosis, etc., demand attention, the nozzle of the discharging tube on the apparatus is inserted between the lips or into a nostril, and the oxygen allowed to flow.

"The effects are so marked as to at once change any novice into an enthusiastic adherent of the method; the dusky, livid hue of the face disappears in a few minutes, while the pulse grows fuller, slower and more rhythmical. When this is fully apparent, the oxygen may be withdrawn. Sometimes twenty or twenty-five gallons answers the purpose. There is a notably

* To Prof. Theophilus Parvin, of Jefferson College, Philadelphia, belongs the credit of its introduction in this country. *Vade* Medical and Surgical Reporter, August 17, 1896.

rapid recovery of consciousness, with almost entire absence of nausea, headache and vomiting, and the latter symptoms do not recur. The avoidance or omission of such causes of extreme prostration after anæsthesia is naturally of vital importance in the case of previously debilitated patients; furthermore, its importance is emphasized in such cases because it permits of the taking of nourishment within a few hours of the severest kinds of operations.

"The after-course of an operation case differs so markedly from all the patient has been led to await, that the latter usually expresses his sentiments thereon in unmistakable language."

Ether or Chloroform—Which?

A valuable contribution, and we again print an abstract from our third edition on this most important subject.*

"Ether is the weaker anæsthetic, possessing the peculiar toxical quality in less degree than chloroform. In small quantity it is decidedly stimulating to the cerebrum and to the vital functions over which the medulla presides; and in this action it is more uniform than chloroform. Indeed, the vital reflexes are so uniformly stimulated by ether, that the danger of its primary effects in healthy subjects is as small as possible under general anæsthesia. In those who take ether well, the stimulating effect on the heart's action and respiration may be observed throughout the anæsthesia. Ordinarily, even anæsthetic doses of ether do not depress these functions, but leave them to themselves, uninfluenced by the general anæsthetic action. Under etherization the heart's action and respiration are certainly less liable to the irregularities, which are not unfrequently observed in chloroform anæsthesia. In the latter stages of etherization, however, the vital reflexes may be depressed, and powerfully, but gradually, so as to give warning of the approach of danger. Ether danger usually approaches by way of the lungs, and usually forewarns by the labored, stertorous, irregular breathing and cyanosis, so as to allow the use

* Dr. A. B. Miles, New Orleans Medical and Surgical Journal (June 27, 1887).

of means to avert. Ether danger, however, may approach by the heart. In ten of forty well-authenticated ether deaths the heart failed first. These deaths resemble chloroform deaths, but comparatively occur much less frequently. So the comparative safety of ether, and its timely admonition of danger, are its chief advantages. They are certainly points of great practical value in its favor.

"Against the merits of ether stand in stronger relief to-day than ever before its disadvantages and its dangers. The advocates of ether, who use it excessively, especially those who yet believe in its absolute safety, are doing much to-day to demonstrate its dangers. Its inflammability in the presence of artificial light, and the actual cauteries, is one objection. The danger of igniting is modified by several conditions: the proximity of the light, its position, and whether exposed or not, the saturation of the surrounding air and the direction of the air currents. Ether may ignite at long distances (fifteen feet, it is said), if the currents set in the direction of an exposed light. But the dangers of inflammability may be modified as above indicated, and much diminished. The exceedingly disagreeable odor, and the irritating property of ether when brought in contact with mucous surfaces, are serious disadvantages. It was this irritating property which refuted the claims of rectal etherization as a warrantable procedure in surgery, but not until it had brought sorrow on its advocates, and a worse fate on some of its victims—diarrhœa, dysentery, hæmorrhage, collapse, death. The irritation of the respiratory mucous membrane usually causes coughing, strangling, and violent resistance. It may cause catarrhal bronchitis and pneumonia. It may very seriously aggravate a pre-existing bronchial or parenchymatous inflammation.

"The excessive secretion which ether causes to flow into the breathing passages is also a disadvantage not to be lightly regarded. This may endanger life by suffocation, especially in cases of pulmonary disease, already attended with free secretion, as in the catarrhal affections of children and old people. It not unfrequently prolongs the asphyxia caused by the usual method of administering ether.

"Patients are usually asphyxiated while being anæsthetized with ether. True, the asphyxia favors the anæsthetic effect of ether, and therefore obviates the necessity of too greatly saturating the blood. But the asphyxia complicates and increases the danger of anæsthesia. The dangers of such a state are beyond question. They are not so immediate as those of chloroform, and, therefore, have been less apparent and less appreciated.

"Asphyxia, as well as etherization, may be carried too far, and at times result disastrously. The respiratory nervous apparatus is exhausted, and the heart fails secondarily. The tone of its own texture is destroyed by the supply of venous blood and by impediment to the pulmonary circulation, its right ventricle becomes overdistended and powerless. So etherization, as much from asphyxia, due to the manner of administration, as from its anæsthetic effect, may depress the heart's action as well as respiration. But the sequelæ of etherization are matters of more serious importance, to which attention is specially directed.

"Aside from the danger of inflammatory diseases, caused by the irritating ether vapor, is the liability to pneumonia, as the result of obstructed pulmonary circulation.

"Again, the asphyxia which goes along with etherization may increase the patient's depression, and retard reaction. The deleterious blood changes in a patient who has undergone prolonged etherization, cannot be well suited to the healing of important wounds. In the suffocating plan of administering ether the blood suffers not alone of the interruption to the interchange of gases, but as much of the rebreathing of excrementitious albuminoid products, which physiologists tell us are so harmful.

"The danger of nephritis, by the action of blood saturated with ether, first pointed out by Dr. Emmet, of New York, has been authentically confirmed by many observers. Healthy organs may be acutely inflamed, and those previously diseased may be greatly aggravated, by the passage of such an irritant over their secretory surfaces. The danger to the kidneys led to the general adoption of the method by forced etherization,

by which the asphyxia lessens the quantity of the ether required.

"Ether, more frequently than chloroform, causes nausea and vomiting. This is an important consideration in the selection of an anæsthetic to be administered in cases in which persistent retching may interfere with the healing of important wounds.

"While the immediate dangers of ether are comparatively slight, those which occur subsequently, to which we have just alluded, are matters of very serious consequence. These dangers weigh heavily against the merits of this anæsthetic.

"Now, let us pass in running review the advantages and dangers of chloroform.

"Its non-inflammability in the presence of artificial light, or the actual cauteries, is an advantage which increases greatly the range of its usefulness. It is certainly the more agreeable to patients, less irritating to the sensory nerves of the respiratory passages and the more enduring in its anæsthetic effect. It causes comparatively little increase of mucous secretion. It is easier of administration, and the mode of administration does not entail any other effect than that of a pure and simple anæsthetic. Chloroform is the more energetic agent, possessing the inherent toxical quality in higher degree than ether. This quality, however, does not differ in character from that which ether possesses.

"The primary effect of chloroform, as of ether, is stimulating to the cerebrum and the vital functions; but the excitement is less intense and of shorter duration than in etherization. Being the more energetic agent, it requires less saturation of the system for the exercise of its anæsthetic power. This is an important consideration. The practical advantages of chloroform in surgery are very striking. These and its comparative freedom from disastrous sequelæ take away much of the terror of its immediate danger.

"The dangers of chloroform are soon told. They are immediate. If patients do not die during the administration they are comparatively safe. *Nearly fifty per cent. of deaths by chloroform occur at the outset of the administration.* The chief danger of chloroform is paralysis of the nervous apparatus

governing circulation and respiration, mentioned in the order of frequency. The centres are taken by surprise by the direct and energetic action of chloroform, and overwhelmed quickly. This sudden action has given to chloroform the name of being treacherous. It teaches unmistakably the necessity of gradually accustoming the centres to the influence of anæsthetics. We dwell on this point with special emphasis.

"A large proportion of deaths by chloroform are reported as occurring suddenly, and without warning. These cases are usually reported in a way to lay all the blame on chloroform. While we do not doubt the extreme susceptibility of some patients, which makes them liable to such fatal accidents, we are constrained to believe that in more instances than recorded there are timely admonitions of danger. These admonitions are irregularities of the heart's action and respiration. Experiments on animals have shown how, under chloroform anæsthesia, the heart is liable to sudden irregularities. Clinical experience confirms the observation. Irregularity of the heart's action, as regards the strength of its beats, is especially ominous. The hesitating, irregular respiration of chloroform anæsthesia is but little less valuable as a warning of danger, and certainly demands more attention than usually given. The statistics, before mentioned, show that in one-fourth of forty cases of chloroform death, respiration failed before the heart's action. Patients who breathe irregularly should be anæsthetized with the utmost caution. These irregularities of the heart s action and respiration indicate a condition of the centres which bears anæsthetics badly. This condition is more frequently observed in the anæmic and weakly, and those under the influence of depressing emotions.

"The dangers of ether and of chloroform are modified by methods of administration. Indeed, we feel safe in venturing the assertion that the dangers of anæsthesia lie not more in the inherent property of the agent employed than in the manner of its administration.

"The risks are very much greater in the unskilful administration of chloroform than in reckless etherization. In view of the danger of its primary effect, we insist here on the advisa-

bility of preparing the way for chloroform. Agents should be given in advance to stimulate the vital reflexes and prepare the nerve centres for the coming anæsthetic effect.

"The old-fashioned whiskey toddy, taken just before the anæsthetic, still has its votaries. The use of alcohol in this way is objectionable. We cannot rely on absorption from the stomach at the very time its stimulating action is most desirable. If given immediately before the anæsthetic, it is not absorbed in time to sustain the centres as they undergo primary anæsthesia. If given in time for absorption, the alcohol antagonizes the action of the anæsthetic. Alcoholic patients are difficult to anæsthetize, and while under anæsthesia they often show alarming symptoms.*

"Again, alcohol is uncertain in the physiological action for which it is given. In many subjects, by abuse, perhaps it may have long since lost its medicinal virtue, while in others its effect may be variable because of nervous susceptibility. Alcohol taken into the stomach before anæsthesia has the effect of exciting many patients after a surgical operation, at the time when it is most desirable that they should be calm. This excitement may increase the liability to inflammation. The maximum good, with the least harm, follows the use of alcohol when administered hypodermatically or by inhalation at the outset of anæsthesia. The first whiffs of chloroform may well be mixed with the vapor of alcohol.

"A few breaths of the vapor of ammonia in advance of chloroform act like alcohol, but more potently, and without its disagreeable effects.

"The method of mixed anæsthesia by the hypodermatic administration of the sulphate of morphia alone, or in combination with a respiratory stimulant, as the sulphate of atropia, is as sound in physiological principle as useful in practice.† The doses of the sulphate of morphia in adults should not exceed one-twelfth to one-sixth of a grain; of the sulphate of atropia, one two-hundredth to one one-hundred and fiftieth of a grain.

* See article on "Alcohol in Operations."

† But not always in practice, on account of idiosyncrasy of patient.

The atropine acts particularly well in states of bronchial catarrh, in pulmonary diseases, and in all cases indicating the action of a respiratory stimulant. The hypodermatic use of morphine, in the doses recommended, secures the primary stimulant effect promptly when desired, aids the anæsthetic in its action, and subsequently promotes the relief necessary after surgical procedures.

"A safe way of preparing the centres for chloroform, and one which we strongly recommend, is by stimulating them primarily with the inhalation of ether. The centres more easily adjust themselves to the action of ether. Statistics show that the danger of the first effect of ether is almost infinitesimal. Thus the anæsthesia is begun with the agent safer at the beginning, and continued with the agent less harmful in its subsequent effects.

"There are causes of danger in the administration of chloroform which occur so commonly as to warrant special mention here. Chief among these common causes of fatal accidents is overdosage—an excessive amount in a given time. Patients being anæsthetized with chloroform should never experience the sense of suffocation of which we too frequently hear them complain. Coughing early in the anæsthesia is usually an evidence of overaction. Chloroform anæsthesia should be begun with minimum doses—a few drops only—and continued to the degree desired in quantities gradually increasing. To overdosage, more than to idiosyncrasy of patients, should be attributed most of the accidents by chloroform. Witness the manner in which so many physicians give chloroform by saturating the inhaler at the outset and forcing the anæsthesia, and there will be less difficulty in explaining many of those deaths that occur with such electric suddenness.

"Haste in the administration of chloroform deserves most emphatic condemnation. The anæsthesia should be produced gradually and maintained uniformly. We believe it unsafe to advise patients at the beginning to 'take long breaths,' with the view of quickly inflating the lungs with saturated air in order to produce a rapid effect.

"In the calm which follows the preliminary excitement,

chloroform acts with increased energy. The centres are at this moment in a state of exhaustion. and not prepared to have the anæsthesia forced. The depression which follows the primary excitement is a period in which much harm may be done by overdoses of chloroform.

"Instead of forcing chloroform anæsthesia at any time during its administration, it is better now and then to give the patient a rest spell, in order to refresh the residual air of the lungs. Some of the singularly sudden deaths, of which we read, may be accounted for by the cumulative effect on the centres, caused by the sudden absorption of vapor which saturates the residual air.

"Recent statistics are not wanting by which we can accurately estimate the relative death-rate caused by ether and chloroform."

On Blood-Alterations by Ether.

In the researches made with nitrous oxide, when given simply to the point of producing anæsthesia for all surgical operations, there occur no true poisonous results. The repeated attempts to produce such a spectrum peculiar to this agent have been, as yet, unsuccessful, the only bands discernible being the broad one between Fraunhofer's D and E lines, which represents the spectrum of reduced hæmoglobin. (See experiments of author.)

In recent years a number of careful observations have been made by reliable observers to determine the amount of hæmoglobin* lost during the anæsthetic state induced by both chloro-

* "Hæmoglobin (hæm-o-glo-bin), hæma, blood, and globus, a round body. Hæmaloglobin, hæmocrystallin; a doubly-refractive, pleochromatic colloid or crystalline matter existing in the corpuscles of the blood, and to which their red color is due.

"In man, the amount is 13.77 per cent.; in woman, 12.50 per cent.; reduced by pregnancy to from 9 to 12 per cent. It is an oxygen carrier or respiratory pigment. The crystals of hæmoglobin have a dark-red appearance, with a strong purple or bluish tint; they are very soluble in water."—*Gould Dict.*

The Blood-Alterations of Ether Anæsthesia, by John Chalmers Da Costa, M.D. Pamphlet, pp. 28. From the Medical News.

form and ether. The following results were obtained by Dr. John Chalmers Da Costa, of Philadelphia. After some preliminary observations on artificially induced unconsciousness, which is known as anæsthesia produced by sudden diminution of the amount of blood in the brain, such as is seen after severe hæmorrhage, ligation of the carotid artery, forcible and rapid respiration, probably as a result of anæmia of the brain, he then points out that anæsthesia may be produced by alterations in the composition of the blood, and the carrying in this fluid of certain extraneous materials to the nerve centres, as exhibited in carbonic acid and narcosis, in which condition the internal respiration is diminished, and the activity of the cerebral cells is depressed or destroyed. Another example of anæsthesia by alteration in the composition of the blood, is seen in the inhalation of ether and chloroform.

"For almost fifty years *ether* has been under scientific investigation, and it is generally agreed that it acts on the nervous system as does alcohol, only far more rapidly. When given by inhalation, there are four stages of anæsthesia :

"1. The stage of stimulation, characterized by excitement and a pleasing intoxication.

"2. The anodyne stage, characterized by impaired sensation, retained reflexes, delirium, which is most marked in robust individuals, tetanic contraction of the muscles, turgescence of the face, etc.

"3. The anæsthetic stage, characterized by the abolition of the ordinary reflexes and of all conscious excito-motor sensibility.

"4. The paralytic stage, characterized by diminution of unconscious excito-motor sensibilities, and, finally, by death from paralysis of the respiratory centre.

"The condition of anæsthesia is thought by most observers to be due to the passage of ether into the blood, and the subsequent direct action of this drug upon the nerve elements. Prevost has sought to prove this by a well-known experiment. He produced unconsciousness in a frog by the direct application of the drug to the cerebrum, after first tying the aorta to prevent the washing away of the agent by the force of the circulation.

The defect in his experiment is the fact that the ligation of the aorta, by depriving the brain of blood, might be responsible for the unconsciousness.

"It seems highly probable, from a series of observations, that the cause of the anæsthetic state is not merely the direct action of ether upon the nerve elements, but involves likewise an alteration in the composition of the blood. It is a well-known fact that slow, chronic, advancing nutritive failure of the brain is first manifest in the decay of the higher and most unstable faculties, which are the last products of evolutionary advance, and that the last faculties to suffer are those that are purely automatic. Consciousness is not lost early in these conditions because cells producing cerebral activities, of which consciousness manifests the sum, have time in chronic failures to adjust themselves to their altering environment.

"That the diminution of the amount of oxyhæmoglobin does tend to produce unconsciousness is shown by the drowsiness, the heaviness, and the tendency to syncope shown by sufferers from chlorosis, by the almost comatose condition of the victims of Winckel's disease, and by the abolition of sensibility of rabbits and guinea-pigs in which this disease has been artificially produced, and yet in these conditions the alteration of blood composition is rather gradual than sudden.

"The following observation will show that diminution in hæmoglobin is constant after the inhalation of ether; that the diminution is rapid and marked, is accompanied by alteration in the shape of the corpuscles, but by no marked diminution in their number. This diminution in the amount of hæmoglobin is so pronounced in the anæmic as to give conclusive evidence of the reason why reaction in these cases is often so difficult, and the effect of the anæsthetic so persistent and prolonged.

"The exact mode in which the hæmoglobin is removed from the corpuscles is questionable. Practically we know that if blood outside of the body is subjected to a low temperature, and subsequently warmed, the coloring matter of the corpuscles passes into the blood liquor. Theoretically we may assume that the rapid evaporation of ether in the air cells of the lungs produces great cold, and that the blood circulating through the

rest of the body becomes subsequently warmed, and the hæmoglobin is thus removed.

"This theory finds apparent confirmation in the rapid lowering of temperature induced by anæsthetics, a lowering that begins with the anodyne stage, and that may reach the extent of four or five degrees. In the cases in which I have made studies of temperature the average fall was found to be from one to three degrees, a fall separated from the fall of shock by the fact of the rapid ascent of the temperature on cessation of inhalation of the anæsthetic.

"The altered shape of the corpuscles may in part be due to the removal of the hæmoglobin, and in part to the dissolving out of some of the fat which they contain. What becomes of the hæmoglobin removed from the corpuscles is a question, though the occasional occurrence immediately after etherization of severe jaundice would seem to indicate that in some cases at least this pigment goes to the liver and is there broken up. In confirmation of the foregoing views I submit twenty-nine cases in which blood examinations have been most carefully made before, during and after etherization.

"The counts were made by means of a Thoma-Zeiss hæmocytometer; the hæmoglobin was estimated by means of Gowers' and Fleischl's hæmoglobinometers; drawings have been made from the undiluted blood, and of necessity are diagrammatic; all forms of the red corpuscles being represented by red; leukocytes, by pale blue; lymphocytes, by dark blue; and blood plates by green. In making the blood counts, the solutions used for dilution were the three per cent. salt solution and the Daland's potassium-bichromate solution.

"The estimation in these cases was made just before etherization, during etherization, and after recovery from the anæsthetic state. Case XIII. was subjected to an estimation three days before the operation, two days before the operation, one day before, and just before operation, during slight anæsthesia, during profound anæsthesia, in the beginning of recovery, and the day after the operation. Case XXIII. died of shock after the operation of gastroenterostomy, and sufficient recovery did not follow operation to permit of estimation being made. The

other cases are free from complication of shock or severe hæmorrhage, and afford pure instances of ether action. Case XIII. was one of examination for stricture of the rectum, a rectal bougie was passed, and there was absolutely no hæmorrhage. Case XXI. was one of attempted reduction of an old inguinal hernia, and was uncomplicated by bleeding. Case XXVII. was one of breaking up of an ankylosis of the finger, and was also unaccompanied by hæmorrhage. Case III. does not show a reduction of hæmoglobin. This apparent discrepancy arises from the estimation having been made without artificial light, and report of this case is made only to maintain scientific consistency; it can be unhesitatingly rejected from the case group. Case XIX. was an alcoholic, never completely under the influence of the ether, and examination showed no apparent fall of hæmoglobin, although after etherization the hæmoglobin was found diminished. This was due to too early observation, the blood being taken during a period of excitement in which there were violent struggling and tumultuous respiratory efforts."

In twenty-seven cases the fall of hæmoglobin is marked and unmistakable. Each case is accompanied by a report of the physical condition of the individual and a urinary examination, with a description of the blood as examined by a Leitz $\frac{1}{12}$ oil immersion, the slide being undiluted blood.

"The hæmoglobin, before etherization, ranged as high as 70; blood examination during etherization was reduced from five to ten per cent. This was an exceptionable case in which the hæmoglobin was increased.

"Case XXVIII.—Patient, W. D., aged fifty-five years. Physical examination negative. Urine examination, negative. Blood examination before etherization: Hæmoglobin, sixty-two per cent. of normal. Red corpuscles per cubic millimeter, total, 4,800,000. Red corpuscles per cubic millimeter, normal, 5,500,000. White corpuscles per cubic millimeter, 10,000. Proportion of white to total red, 1 : 480. Proportion of white to normal red, 1 : 450. Appearance of corpuscles practically normal.

"Blood examination during etherization: Hæmoglobin, fifty-five per cent. of normal. Red corpuscles per cubic millimeter,

total, 5,000,000. Red corpuscles per cubic millimeter, normal, 3,000,000. White corpuscles per cubic millimeter, 12,000. Proportion of white to total red, 1 : 417. Proportion of white to normal red, 1 : 250. The slides showed normal red, irregular red, and granular leukocytes.

"Blood examination after etherization. Hæmoglobin, sixty per cent. of normal. Red corpuscles per cubic millimeter, total, 4,480,000. Red corpuscles per cubic millimeter, normal, 2,000,000. White corpuscles per cubic millimeter, 12,000. Proportion of white to total red, 1 : 370. Proportion of white to normal red, 1 : 166. The slides showed normal red, diseased red, and granular leukocytes."

An accurate detail of twenty-eight cases is given and the following conclusions are reached :

"1. Etherization produces a marked diminution in the hæmoglobin of the blood.

"2. The red corpuscles and the hæmoglobin are especially affected in blood previously diseased, in such conditions, for instance, as anæmia."

"3. Irregular reports are due to faulty observations, to the presence of altered hemoglobin in the blood, to the faulty aberration as to color of Fleischl instrument or to taking the blood before anæsthesia is complete.

"4. The white corpuscles show irregular changes which are not characteristic, and exhibit variations not more pronounced than would be found in the same number of samples of normal blood on different examinations.

"5. Age does not apparently influence the results.

"6. Ether-pneumonia may possibly be due, in some instances at least, to the action of intense cold upon the lungs, produced by the action of ether-vapor.

"7. Œdema of the lungs may arise from contraction of the pulmonary capillaries, thus producing a loss of *vis a tergo* and damming up of blood in the veins. Furthermore, the same condition may produce sudden paralysis of the heart.

"8. The often-quoted observation as to the effect upon the hæmoglobin of shock and hæmorrhage requires enlarged repetition upon human beings before the statement can be unre-

servedly accepted, that hæmorrhage causes a great fall in the amount of hæmoglobin, but that shock does not affect it.

"9. The chilling of the blood-stream may be responsible for the nephritis that occasionally follows etherization.

"10. Prolonged anæsthesia profoundly deteriorates the blood and strongly militates against recovery; hence the rapidity of operation is most desirable."

These observations and experiments will require confirmation.

The Influence of Anæsthetics on the Kidneys, More Especially Ether and Chloroform.

Under alcohol we have shown the effects of alcohol on the kidneys and liver, by the late coroner's physician of Philadelphia, Dr. H. F. Formad. We now extract from a late pamphlet of Dr. H. C. Wood's some valuable facts by him, and experiments of his son, Dr. George B. Wood, on this same subject. We are pleased that so high an authority as Dr. Wood so fully agrees with the importance of the careful examination of the kidneys, and the importance of recording the habits of the patient in regard to the constant use of stimulants, especially alcohol.

"KIDNEYS.—Writing in 1890, Dr. Laurence Turnbull said that 'it is of the greatest importance that attention should be given to the condition of the kidneys, and an examination made of the urine when an anæsthetic is to be administered. Deaths, unaccountable otherwise, are due to this cause. In diseases of the kidneys, the blood being loaded with urea, anæsthetics almost invariably produce convulsions, coma and death.' These words of Dr. Turnbull reflect a widespread professional opinion. If, then, disease of the kidneys be so strong a contraindication to the use of anæsthetics, it is necessary to examine very carefully as to the proper choice of the anæsthetics when, notwithstanding the existence of renal disease, anæsthesia must be superinduced. It is plain that two distinct dangers underlie the use of the anæsthetic in renal disease; one has to do with the influence of the drug upon the diseased kidneys; the other has to do with the relations between the secondary conditions

of Bright's disease and the anæsthetic. Marked atheromatous arteries contraindicate nitrous oxide; a degenerated heart-muscle contraindicates chloroform; and it may very well be that sometimes the choice of the surgeon should light upon the anæsthetic which threatens the kidneys most, because it is the least dangerous to those organs which have become secondarily diseased.

"As throwing light upon sudden death during anæsthesia it is worthy of note that in Dr. George B. Wood's experiments, referred to below, several times in dogs who were suffering from nephritis artificially produced by the use of cantharides or present as the outcome of natural disease, sudden fatal arrest of respiration occurred, suggesting that there may be in uræmia or uræmic conditions a special inability of the respiratory centres to resist the effects of narcotic poisons, and that amongst the secondary effects of Bright's disease should be put lack of resistive power in the respiratory centres.

"In attempting to decide as to the choice of an anæsthetic for an uræmic patient it is proper first to study the relations of the anæsthetic to the kidneys themselves. So far as my reading goes, Dr. Thomas A. Emmet, of New York, was the first to call attention to the possibility of the production of fatal suppression of urine in persons suffering from chronic Bright's disease by the use of ether. In his first experience complete suppression, and death in three days from uræmia, occurred in a patient suffering from chronic cystitis and probably renal degeneration. Subsequently to this Dr. Emmet is said to have had five such cases. Without attempting to go over the whole literature of the subject, attention may be called to the cases reported by Professor W. F. Norris to the American Ophthalmological Society in 1881, especially to the one in which death in convulsions followed ether anæsthesia in a child suffering from fatty kidneys, and in which after death the kidneys were found intensely congested. Various cases similar to these have been published in medical literature, and it does not suffice to answer, as has been done, that ether has been frequently employed in Bright's disease without bad results.

"It ought to be possible to positively determine whether or

not ether is capable of affecting the secreting structure of the normal kidney. In the *British Medical Journal* Dr. Lawson Tait records a remarkable case, in which, the ureters being exposed, it was found that the continuous administration of ether prevented the secretion of urine, and so long as the narcosis persisted there was no flow of urine. This observation is said to have been repeatedly confirmed by Tait himself, and is of great importance as evidence that ether does affect the human kidney. It is evident that experiments upon animals should be made, in which, the ureters having been exposed and canulated, it should be determined whether these observations of Tait are exceptional or not. Albuminuria after ordinary anæsthesia is probably rare, but it certainly does occur at times. Patein found it once in every three cases, but this is plainly much above the average. In elaborate studies made in the physiological laboratory of the University of Pennsylvania by my son, Dr. George B. Wood, it was found in dogs that during ether anæsthesia the kidneys become markedly congested, and almost invariably, if the anæsthesia had been protracted over fifteen minutes and the dog then killed, it was possible to demonstrate cloudy swelling of the nuclei and contents of the secreting cells. The cells of the convoluted tubules were those primarily affected, the tufts and corresponding tubules only showing change when the anæsthesia had been greatly prolonged. It is true that Fueter failed to detect changes in the kidneys of etherized dogs, but this negative testimony can hardly stand against the positive evidence with specimens which were studied and accepted as conclusive by Dr. Guiteras, professor of pathology in the University of Pennsylvania."*

* University Medical Magazine, vi., 1894, p. 802.

CHAPTER VII.

Hydrobromic Ether or the Bromide of Ethyl—Chemical Nature, Properties, Decompositions, etc.—As an Anæsthetic in Labor, in Dental Operations—Table of the Purity of Various Specimens of Bromide of Ethyl.

Hydrobromic Ether or Bromide of Ethyl. ($C_2H.Br.$)

PROPERTIES.—Bromide of ethyl ($C_2H_5Br.$), or "hydrobromic ether," is a colorless liquid, with an agreeable odor; it boils at about 40.7° C. (105.8° F.); has a density of 1.475 at 15° C. (59° F.); the boiling point and the density, are, therefore, intermediate between those of chloroform and sulphuric ether.

THE MODE OF PREPARATION.—Distil a mixture of 4 parts of bromide of potassium, 4 parts acid sulphuric and 2 parts alcohol. This is the formula of the French Codex of 1884. To cheapen it they now introduce into a tubular retort, surrounded by ice water, 30 to 40 grammes of red phosphorus, and 200 grammes of very concentrated alcohol, in which was dissolved 200 grammes of bromine.

We thus produce hydrobromic acid, which reacts on the alcohol in a nascent state, the whole is left to digest for some time, then distilled and is precipitated by water, the condensed product is then decanted and the heavy liquid falling to the bottom is digested on chloride of calcium to dry it.

Bromide of Ethyl. ($C_2H_5Br.$)

Transparent and colorless liquid, heavier than water (Serullas); specific gravity 1.40 (Löwig), 1.4733 at 0° (Pierre); vapor density 3.754 (R. Marchand J. per cm. 188); very volatile; boiling-point 40.7° C. when the barometer stands at 757 mm. (Pierre); has a strong ethereal odor and pungent taste (Serullas). According to Löwig, its taste is strongly and agreeably sweetish, with a somewhat burning after-taste. The vapor, when inhaled, exerts an anæsthetic action, like chloroform (Robin, *Compt.*

Rend. xxx. 669). It is sparingly soluble in water, but mixes in all proportions with *alcohol* and *ether*.

DECOMPOSITIONS.—1. Vapor of hydrobromic ether passed through a glass tube at a low red heat is resolved into ethylene and hydrobromic acid gas. 2. It burns with difficulty, but with a beautiful green flame, which does not smoke, a strong odor of hydrobromic acid being at the same time evolved. 3. It is not decomposed by nitric acid, oil of vitriol or potassium. 4. With ammonia it yields hydrobromate of ethylamine.

The hydrobromic ether or bromide of ethyl was discovered by Serullas, in 1827, but received no special attention until Dr. Thomas Nunnelly, of Leeds, reported some experiments made with it on animals in 1849. Dr. Nunnelly brought the subject again before the profession by a paper read at the meeting of the British Medical Association in 1865, in which, speaking of it in conjunction with another anæsthetic, he said he had for some time employed the one or the other in all the principal operations at the Leeds General Eye and Ear Infirmary. This was at a time when chloroform held such complete sway in England that no importance was attached to Nunnelly's experience or experiments. He had no one to follow him in using it; and we hear no more of it until 1876, when some experiments were made with it in France, by Rabuteau, on the lower animals, but evidently without a knowledge of the fact that this had been done previously in England by Nunnelly.

The writer then took the agent up without the knowledge of the experiments of Dr. Nunnelly. He had it made in Philadelphia by Professor Remington, and with two friends began experimenting in September, 1877, using it first on himself and then upon his patients.

Physiological Action of Bromide of Ethyl.

The physiological action of bromide of ethyl has been studied by the author and other observers. A peculiarity that has been noted is a tendency for sensibility to be lost and pain relieved before consciousness has been completely destroyed, so that short operations can be done at that stage. There is not always complete relaxation of the muscles, as in the use of ether. If

the bromide of ethyl is impure, such as was employed in the Jefferson Medical College Hospital by the late Dr. Levis and others (see p. 235 for chemical examinations), general tetanus and even opisthotonus with increase of hæmorrhage must have occurred from free phosphorus, as no such results have been noticed, as is stated by Dr. John H. Brinton (*Therap. Gaz.*, v. 3), which has followed the operation; this has not been noted by any other surgeon that we can find any record of.

The subject has been also studied by Schneider, Aboneje, Thornton and Maxwell (*Therap. Gaz.*, 1892) and by Wood (*Theraps.*, 9th ed.). Schneider states that the arterial pressure does not fall until very late in the bromide narcosis, and that death takes place always through arrest of respiration. In those statements he is in accord with results obtained by Aboneje (*Wiener Klinik*, 1891, Heft. 1), which agrees with our own experiments, while Wood (*op. cit.*) endeavors to show that the arterial pressure occurs very early and increases steadily with persistent inhalation (beyond the point of true anæsthesia). This his young friends (Thornton and Maxwell) endeavor to confirm, but we think not with success. We feel sure that the bromide of ethyl, in its action, is not at all like chloroform, and we fear that Dr. Wood has not had very pure specimens of the drug for experimentation. For he states: "It is possible that this difference of result has depended upon some of the bromide of ethyl used (we add, by himself and friends) being impure."

In few instances, recently, the use of this anæsthetic has been attended with persistent vomiting and free secretion of mucus owing to impurities, though in the thousands of cases in which it has been employed, chiefly in Philadelphia, in not one single instance has it caused cerebral trouble, or any of the symptoms produced by the action of free bromine. We have experimented upon frogs, cats, dogs, rabbits and various other animals by subjecting them to an atmosphere highly charged with the vapor of hydrobromic ether, and in rare instances were there the effects described above.

In some recent experiments on animals we crowded four ounces upon a dog by means of a tin inhaler, until he became

apparently dead, with no perceptible action of the heart or lungs; but the expression of his eye was clear and the pupil was dilated, while there was no secretion from the eyes or nostrils. The apparatus was removed in the space of four minutes, and he was exposed to the air, when at once he began to breathe, and by the end of six minutes he had entirely recovered consciousness. The dog did not seem much inclined to move for ten or twelve minutes afterwards. While this dog was only partially under the influence of this anæsthetic, having at first caught the inhaling apparatus between his teeth, there was a good deal of rigidity and slight tetanic movements of the extremities, but this was overcome by the free use of the ether. Had we been using chloroform, just before he would have come completely under its full influence, he would have died. Numerous dogs were lost every season when experimenting upon them, so that now chloroform alone is rarely employed in the laboratory for experimental purposes.

Vernuil, at the meeting of the Société de Chirurgie, stated that one patient, a woman, to whom he had given the vapor of ethyl bromide, was asleep in an instant; and Terrillon stated that anæsthesia may be produced in less than a minute. In our own experiments, the shortest time necessary for primary anæsthesia was thirty seconds.

The bromide of ethyl is costly, from the great care required in its preparation; and the great demand for it has caused many imitations to be placed on the market. The importance of its purity was at first so little understood that the original manufacturers did not take sufficient time to purify it.

Mode of Employment.

1. All tight-fitting garments in and about the neck and chest should be loosened and the patient lay down.

2. The ethyl vapor must be inhaled at first with atmospheric air. The best form of inhaler is a thick towel, folded in the form of a cone, closed at the apex with a large pin; between the folds of the towel place a sheet of newspaper or rubber. The base of the cone must be wide enough to include both mouth and nose.

3. Instruct the patient, in advance, to make deep and long inspirations. In the cone place about from 75 to 150 drops for the adult, and 50 to 100 for the infant, by measure. At once cover the nose and mouth with it, and do not remove the cone until anæsthesia is produced.

The anæsthetic sleep will not last more than from two to three minutes. The patient retains the usual healthy color of lips and skin, and the pulse first becomes rapid, then slower and stronger, as the narcosis becomes profound. The patient, as a rule, awakens suddenly and completely, but if there is nausea or much agitation it is best for him to remain quiet and in a horizontal posture for some time.

Dr. Koellicker, in some recent observations, recommends the bromide of ethyl in a great number of small operations in surgery. His method is: place the patient decubitis dorsal, and gives careful direction in examining, in every case, the heart.

He employs a mask of thin rubber and a layer of flannel from ten to fifteen grammes for the adult and five to ten for the child. You pour a few drops of bromide of ethyl, and in a few seconds the whole quantity; the anæsthesia takes place in the course of one minute; we tell the patient to hold the arm up, and then the operation can be performed.

We did not often advise that bromide of ethyl should be resorted to in protracted operations, and we never have employed it in any case longer than forty minutes, and have never used more than four ounces of the pure ether in any one case.

In more than one hospital they were furnished an ethyl bromide that was impure. It was prepared with phosphorus, bromine and alcohol. The phosphorus employed was impure; it gave out hydrogen phosphide, which caused the alliaceous odor noticed in patients who had been anæsthetized by this method. The ethyl bromide should be prepared with sulphuric acid, ethylic ether and potassium bromide; this method gave a much purer product. Ethyl bromide contained then a larger proportion of ethylic ether, and was preferable to that used in the hospitals. M. Bazy had observed that vomiting rarely fol-

lowed anæsthetics with ethyl bromide alone, but thought it not so in mixed anæsthetics, as with the latter method in the case of a child he had observed abundant vomiting on the patient's return to consciousness.*

The most recent views of Professor Wood on the subject of bromide of ethyl is as follows: "At least one, and probably more, deaths have been produced by the substitution of the bromide of ethyline for the bromide of ethyl." (See *Therap. Monatch.*, 1889, Vol. III.)

Dr. Gilles claims (*Berlin Klin. Wochensh.*, Vol. XXIX., 1892) there were given in Germany during three years twenty thousand administrations without a single fatal result on record in which it has been proved that a chemically pure bromide has been administered.

Dr. Wood† concludes as follows: "Our present knowledge appears to indicate that an absolutely pure bromide of ethyl is a proper substance for the production of brief anæsthesia. This is all that the author of this work ever claimed for it." (See 3d Edition, article "Ethyl Bromide.") Magill advocates the rapid induction of anæsthesia by means of ethyl bromide and the substitution of chloroform to maintain unconsciousness. He maintains that ethyl bromide cannot produce primary syncope from naso-pharyngeal reflex, that it stimulates cardiac action and is less toxic.‡

The ethyl bromide is given on a folded towel, and after three or four inhalations the patient loses all sense of touch or pain, but is still conscious. Complete unconsciousness is induced in about one minute and chloroform substituted. In spite of recorded fatalities from ethyl bromide, Magill believes it to be a safe agent when pure, and holds that some deaths assigned to it were really induced by other causes.

Ethyl Bromide as an Anæsthetic.

The *Gazette Medicale de Paris* for May 12, 1894, contains a report of the proceedings of a meeting of the Academy de

* New York Med. Journal, June 9, 1894, p. 733.

† Therapeutics, H. C. Wood, 9th Ed., p. 151.

‡ Internat. Med. Mag., June, 1894.

Medicine, at which M. Suarez de Mendoza, of Angers, related the case of a woman who had died suddenly during the first inhalation of ethyl bromide. The death, he said, should be attributed to cardiac syncope, provoked by the action of the vapors of this anæsthetic on the ends of the nasal nerve (details not given of operation or post-mortem). The same journal publishes a paper on the subject of ethyl bromide as an anæsthetic, which was read before the Societe de Chirurgie by M. Terrier. The author remarks that he has employed ethyl bromide alone or mixed with chloroform for a long time, both in hospital and in his private practice. He had such variable results from the use of this anæsthetic that he felt it was his duty to analyze several specimens, and found them impure.

Some Recent Observations on Mixtures of Bromide of Ethyl.

"Eschawzier," an assistant to a dentist of Brooklyn, had the misfortune to lose a patient from this mixture of bromide of ethyl and oil of roses, so-called soporative, after the extraction of a tooth. He had no assistant, and operated in the ordinary manner. The lady recovered from the anæsthetic and shortly after was attacked with syncope and choked. Had he elevated her feet and depressed her head, or drawn out the tongue, all would have been well, but nothing was done, as no medical man was present. The cause of death was stated to the jury as asphyxia and pulmonary congestion. She was stated to have had a fatty heart, but as there was no post-mortem we do not know how the non-medical man arrived at this conclusion. But this was for the jury, who exonerated the dentist's assistant, but wisely recommended that in all doubtful cases the patient should be examined by a competent medical man before the anæsthetic be administered.

This is a lesson to those who employ mixtures, which are never as safe as the agent alone, which should be well studied by the dental or medical man before being employed.

We regret to learn that under the term vitalized air there are found mixtures of ethyl bromide, ether, alcohol and even chlo-

roform. These mixtures are termed "proprietary anæsthetics." Our attention, says the editor of the *Dental Cosmos*, has again been called to this subject by a correspondent, who enclosed a circular announcing a "new discovery for producing natural sleep at will; safe and efficient for extracting teeth without pain or danger; indorsed by the leading medical journals in Europe and America."

The proprietor of this wonderful agent claims that it was discovered after years of labor and research; that since 1864 he had been constantly on the alert for some agent that would be more efficient, safe and economical than nitrous oxide. He appends statistics showing its relative economy, and testimonials as to its safety and efficiency. He claims that he was led to the investigations which resulted in the discovery of this new anæsthetic from the conviction that "progressive science devises means for producing natural sleep at will," and he therefore determined to investigate and discover, if possible, some agent that would not be open to the objections which appertain to chloroform, ether and nitrous oxide gas, all of which he considers unsafe because they produce congestion of the brain, and death is likely to result from such abnormal condition; and that the new anæsthetic produces natural sleep without congestion, and is therefore absolutely free from danger, and that "heart disease, pregnancy, lactation, menstruation, kidney troubles and old age are no drawbacks in its administration." The discoverer of this new anæsthetic has given it the name of "soporative," the word being derived from the Latin soporo, meaning natural sleep, as we are informed in the circular.

Realizing at once the value which an agent of this character would have in the practice of medicine and dentistry, we procured a bottle direct from the proprietor, at a cost of five dollars, at once submitted it for analysis, and have received the following report thereon :

PHILADELPHIA, March 29, 1886.

To the late J. W. WHITE, M.D.,

Dear Sir: The sample of "Soporative" received from you

on the 24th inst. has been examined. It is Bromide of Ethyl, flavored with rose, and containing distinct traces of alcohol, as follows:

Bromide of Ethyl, . . .	99.13 per cent.
Alcohol and Oil of Rose, . .	.87 per cent.
	100.00

Yours truly,

HENRY TRIMBLE,

Professor of Analytical Chemistry in the Philadelphia College of Pharmacy.

There are still dangerous mixtures kept up to the present day by advertising in our first-class dental journals.

The following are examples of impure specimens of pure ethyl bromide:

No. 7.—The sample is first left in contact with the sodium amalgam alone after color reactions are obtained, the water is added. This sample, we may remark, was furnished Dr. William Brodie, of the Therapeutic Gazette, and Dr. J. Marion Sims. It is a portion of that employed by this distinguished surgeon in the fatal case with the details of which the profession is so familiar in our third edition.

Professor Jungk received an additional consignment of various commercial brands of bromide of ethyl. As the time for making further tests was too limited to take in hand more than a single sample, he selected for the purpose one purporting to have been used by Dr. Levis, of Philadelphia, in the fatal case which occurred in his practice from the effects of this anæsthetic, which sample consisted of about two fluid ounces, and was contained in a bottle with the name "Jefferson Medical College Hospital" blown in the glass. The reaction obtained with this sample resembles very much that of No. 7, with additional formation of a turbidity, which is not soluble in nitric acid. The reaction of this sample, as well as those obtained with Nos. 1, 4, 6 and 7, demonstrate conclusively their entire unfitness for the purpose of inhalation. No records of the deaths from ethyl bromide, have been transferred from the third

edition, but every case since 1890 has been published by the author.

Dr. E. E. Montgomery's Opinion on the Value of Ethyl Bromide in Obstetrics.

"We have used the drug in twenty-nine cases, and have become so well pleased with its action as to regard it a necessity in the practice of obstetrics.

"In the use of a new anæsthetic, and one which, from its recent use, must necessarily be regarded with suspicion, we have been extremely careful in observing and noting its effects.

"Of these cases, eight were primiparæ, and twenty-one multiparæ; in the former, delivery was completed five times with forceps, in the latter eleven times.

"Analyzing these cases further. discloses that:

In 5, ethyl was not given until the forceps were applied.

In 3, labor was completed naturally, where previous labors were instrumental.

In 1, former labor was also instrumental.

In 3, labor-pains were weak before, and after, administration of the drug.

In 2, pains were weak, but strength greatly increased after its administration.

In 2, the fœtus presented with vertex in R. O. P. position.

In 1, delivery followed by uterine inertia, inversion and hæmorrhage.

In 1, fœtus still-born.

In 1, child died same day, in convulsions.

In 1, child died second day, of cyanosis.

"In the presentation of any anæsthetic for general obstetric use the profession have the right to demand that it shall be shown to be absolutely safe for mother and child; that it will not cause uterine inertia, thus increasing the danger of post-partum hæmorrhage, nor induce acute inflammatory conditions in the organs, by which it is eliminated, complicating the puerperal stage.

Details of Cases in Our Last Edition.

BEFORE ADMINISTRATION.		AFTER ADMINISTRATION.	
Time of beginning.	Length.	Time of beginning.	Length.
11′, 13″, 30‴ P.M.	30‴	11′, 40″, 45‴	30‴
11′, 15″, 45‴	30‴	11′, 42″, 30‴	1″
11′, 19″	1″, 30‴	11′, 44″, 30‴	45‴
11′, 21″, 20‴	1″	11′, 46″, 30‴	1″
11′, 22″, 45‴	30‴	11′, 49″, 15‴	1″
11′, 25″, 20‴	1″	11′, 52″	30‴
11′, 27″	30‴	11′, 54″	1″
11′, 28″, 45‴	2″, 30‴	11′, 56″	1.15
Total T. 17″, 45‴	Total L. 8″	T. T. 16″, 30‴	T. L. 7″

"We have noticed a marked want of uniformity in the action of different preparations of this drug. Some, procured for use in the Philadelphia Hospital, had an unpleasant irritating odor, and were slow in producing the anæsthetic effect. To this fact we are inclined to ascribe the want of action experienced by Müller in a number of his cases. We have been in the habit of specifying either Merck's or Parke, Davis & Co., when procuring it, as we have invariably found their preparations of the drug with a pleasant odor, and reliable in action.

"We feel that the experience derived from our own cases, together with the commendation of other experimenters, justify us in urging upon the profession a more extended trial of this agent in alleviating the sufferings of the most trying period of maternal life."

Bromide of Ethyl.

The following letter will show that Dr. Montgomery still retains his faith in the use of a pure bromide of ethyl, which he has now used for six years with the due care and caution with which every anæsthetic should be thus employed :

"PHILADELPHIA, February 11, 1896.

"LAURENCE TURNBULL, M.D.,

"255 South Seventeenth Street.

"*My Dear Doctor:* Your letter of February 10th is at hand, I find no reason to lose faith in the value of bromide of ethyl

as an anæsthetic for short operations and examinations. I am using it constantly.

"Very sincerely yours,

"E. E. MONTGOMERY,

"*Professor of Clinical Gynæcology,*

"*Jefferson Medical College, Philadelphia.*"

Anæsthesia by the Bromide of Ethyl.*

The bromide of ethyl has been extensively employed of late by the dentists of Germany and in the minor operations in surgery of short duration. It should be administered in the following manner:

While the patient is becoming accustomed to the odor of the anæsthetic, no external impression must be given, nor noise made by those around him. Skinner's apparatus should be used, lined with rubber and covered with a piece of flannel, upon which is poured a few drops of the anæsthetic, so as to exclude all air. The anæsthetic requires from fifty to sixty seconds, and lasts three minutes.

The requisite amount is from five to ten grammes for an infant and ten to fifteen grammes for an adult, with no unpleasant results. This anæsthesia has been found very convenient for incisions in abscesses, etc., tenotomies of tendons, the application of the thermo-cautery, extirpation of small tumors, and for quickly emptying a tubercular deposit.

Bromide of ethyl is a nervous sedative, and is employed in epilepsy, hysteria, etc. Dose, for internal use, five to thirty drops in sugar, or, better, in capsules; must be kept from light, heat and air; and, to obtain pure, ordered in sealed tubes. Be sure not to order bromide of ethylene, which is poisonous if employed in spray or by inhalation, Dose, 150–300 M.

* By Dr. Kolliker (Centralblatt für Chirurgie. No. 20, p. 385, 1891).

PART FOURTH.

CHAPTER VIII.

Chloroform—Dichlorinated Chloride of Methyl—Terchloride of Formyl ($CHCl_3$).

Chloroform.

The ordinary method of preparing chloroform is by the distillation of alcohol and chloride of lime ; but owing to the heavy duty upon alcohol the following methods will show that it can be manufactured at less cost. One of these new processes consists in the substitution of wood alcohol (this is one-third less in price than grain alcohol).

When wood is subjected to destructive distillation, the result is pyroligneous acid and pyroxylic spirit, commonly called wood alcohol. The latter is separated in a very impure state, redistilled with lime, and then manufactured into chloroform, and is purified in the ordinary way with chloride of lime and sulphuric acid. The manufacture of chloroform from pure wood alcohol is not entirely new, but the value of the patent consists in the fact of being able to use the alcohol in a crude or intermediate state before it is separated from the pyroligneous acid and the other liquid constituents of wood, thus reducing the cost to a minimum.

Chloroform prepared from wood spirit is specifically lighter, and has at times an empyreumatic odor from acids or chlorinated

oils, and gives rise, when inhaled, to unpleasant sensations, with prostration and headache. Many chloroform accidents are doubtless due to impurities in the drug. Sleep is obtained with difficulty, and is disturbed in character. In some cases, to induce sleep, the attempt has had to be given up, as the impure chloroform only produced irritation of the lungs and stomach, inducing vomiting, etc.

An Improved Chloroform.

The new process for the manufacture of chloroform we quote from no less an authority than Sadler:*

"The raw material from which chloroform is made is the gray acetate of lime. While this is distinctly purer than brown acetate, it still contains both moisture and tarry matter. To free it from these and to raise the percentage of actual acetate of lime, it is carefully roasted before being submitted to dry distillation. This roasting forms the subject of patent No. 393,079, issued to Gustav Rumpf, of Frankfort, Germany, and assigned to Roessler and Hasslacher, of New York. It is done in a series of three slightly inclined cylindrical retorts, in which the material is continually pushed forward by revolving blades. The gray crude acetate is dropped in and passes along the length of the upper retort, until it drops upon the blades which revolve in the second retort, and, passing along this, is dropped into the third or lowest retort, from which it issues and is collected in suitable vessels. By this continuous rotating process the crude material can be purified without notable decomposition of the true acetate.

"The patentee claims that 'in the process of subjecting acetates in a closed vessel to heat applied externally to the vessel for distilling acetone from the acetates, the desired slowness and uniformity of temperature may be secured by stirring the acetate, so that all portions of the mass will be subjected to the heat resulting from direct contact with the bottom of the vessel, and by admitting free steam from time to time into direct con-

* Pharmaceutical Record, August 19, 1889, Samuel P. Sadler.

tact with the acetates in case of any undesirable rise in temperature within the vessel.' "

This is effected by mechanical agitation provided for by the paddles which rotate around the vertical central axis. Steam is admitted by one of the openings above, while the products of distillation pass off by another opening in the top of the retort. The crude acetone distillate so obtained, while richer than before in real acetone, still contains oily distillation products and much water from condensed steam. In this dilute state it is treated with milk of lime to remove the higher ketones and other compounds. It is then distilled from a large plain still, and the fractions rich in acetone passed to a column still, where it is rectified until it becomes almost if not quite anhydrous. In practice, two column-still rectifications are carried out, one after the other, so that the pure acetone shows 99° or 100° by the alcoholometer. It is now fitted for use in the direct manufacture of chloroform. The process and form of apparatus for most successfully carrying out this chloroform manufacture, constitute the subject of United States patent No. 383,992, also issued to G. Rumpf and assigned to Roessler and Hasslacher. The patentee first states, that in order to get the full yield of chloroform, it is necessary to take a much larger proportion of bleaching powder than that given in "Watts' Dictionary of Chemistry," Vol. 1, page 918, and states that for 58 pounds of acetone at least 600 pounds of chloride of lime of thirty-five per cent. available chlorine are necessary. The yield will then be from one hundred and fifty to one hundred and eighty per cent. of the weight of acetone employed instead of about thirty-three per cent.

The still having been filled to a proper height with water, the charge of bleaching powder is introduced, and the man-hole closed with cement. The agitators having been started by means of the revolving shaft, the acetone, previously diluted, is pumped in gradually. As it enters, it rises and reacts with the bleaching-powder solution, and the chloroform produced, distilled spontaneously from the delivery tube, passes through the condenser, and is collected under water. The introduction

of diluted acetone is to be effected at intervals only, otherwise some will distill over unchanged, or the reaction will become too violent, and much frothing ensue. When the delivery of chloroform begins to slacken, steam is gradually introduced to heat up the mixture and drive over the last portion of chloroform which remains. The contents of the still are then discharged into a drain. They consist of very dilute calcium acetate solution mixed with calcium hydrate and calcium chloride.

The reaction for this production of chloroform from acetone seems to be simply

$2C_3H_{60} + 6CaOCl_2 = 2CCl_3H + Ca(C_2H_3O_2)_2 + 2Ca(OH)_2 + 3CaCl_2$. This would demand one equivalent of chloroform for one of acetone used, or 206 parts of chloroform by weight reckoned on the weight of the acetone. In practice, 180 parts are usually obtained, although 200 parts have actually been obtained at times.

The chloroform obtained is quite free from the chlorinated side products which often accompany the chloroform made from impure alcohol. It is, nevertheless, thoroughly purified by treatment with sulphuric acid and careful washing, and is then brought exactly to the United States Pharmacopœia standard.

Commercial chloroform when obtained is a transparent, heavy liquid containing ninety-eight per cent. of chloroform, frequently containing hydrochloric acid, chlorine, and foreign chlorine compounds, with traces of arsenic as impurities. It is therefore unfitted to use as a medicine, or as an anæsthetic agent, until purified.

Chloroformum Purificatum—Purified Chloroform.

($CHCl_3$; 119.2—CH_2Cl_3; 119.2.)

After careful purification, by means of redistillation, in contact with sulphuric acid, carbonate of sodium, lime, potash, alcohol and water, it is then ready for use. Chloroform, in its pure state, is a heavy, clear liquid, having a specific gravity of

1.49°. It has a characteristic, pleasant, and ethereal odor, a burning sweet taste, and a neutral reaction. It dissolves in alcohol and ether in all proportions, but only mixes with water in small proportions, and will, after a time, sink to the bottom of such mixtures in clear globules, owing to its being so much heavier. It communicates its sweetish taste to water. Dose, 3 to 10 min. given in capsules, or mixed with alcohol as the spiritus chloroformi, 1 volume in 20. Dose, 20 to 60 min., or in the mistura chloroformi—chloroform 8, camphor 2, fresh yolk of egg 10, water 80. Dose, tablespoonful. If a few drops be permitted to evaporate from blotting paper, no stain, or no foreign odor should be perceptible after the odor of chloroform ceases to be recognized. When applied to the skin, chloroform evaporates rapidly, and produces a feeling of cold. When the evaporation is prevented, it passes through the epidermis, and acts as an irritant to the inner skin, producing rubefaction and local anæsthesia. (See article on Local Anæsthetics.)

No chloroform should be used for anæsthetic purposes which does not comply with the following requirements:

1st test. When dropped in distilled water, there should be transparent globules with no milky appearance.

2d. Chloroform should have an agreeable odor.

3d. It should not redden blue litmus paper.

4th. When added to a solution of nitrate of silver, it should not form a precipitate, nor even cause cloudiness.

5th. Test with a solution of iodide of potassium (for free chlorine).

6th. When brought to the boiling-point with a concentrated solution of caustic potash it should not become colored. (Absence of aldehyde and arsenic.)

7th. Sulphuric acid should not blacken it when brought in contact with chloroform.

8th. Mixed with concentrated sulphuric acid and shaken, it should separate in half an hour into two colorless layers.

Chloroform is liable to sudden changes, and exposure to light, an imperfect stopper, or partially filled bottle frequently affect its purity; hence, it should be tested before using. The com-

bined action of permanganate of potash and a caustic alkali has been recommended as an exceedingly delicate test and reagent.

Mode of Administering Chloroform.

To inhale (inhalo) is to inspire or draw air, either alone or charged with vapors of various volatile agents, into the lungs.

When chloroform was first discovered as an anæsthetic the apparatus employed was that designed for etherization, but of a more reduced size. It was found that the less volatile nature of chloroform permitted even the abandonment of all complicated apparatus, and most physicians and surgeons preferred to use a handkerchief or a compress of linen folded to several thicknesses (some even preferring to have it starched so as to retain its shape). After having arranged the folds (using a safety-pin to hold them together) in a cup shape, on this linen drop several drops of chloroform from a graduated bottle (so as to be able to measure the quantity employed). Apply over the mouth and nostrils of the patient, allowing however at the beginning enough free space for the atmospheric air to enter with the chloroform. If the subject be nervous, irritable and manifest a feeling of suffocation, remove the compress still further, and even mix a small portion of cologne water until the patient becomes accustomed to the odor.

The chief objection to this mode of employing the chloroform is the waste and the tendency of the moist cloth to adhere to the parts and irritate the skin. Efforts were then made to overcome or diminish these objections by the use of a more complicated apparatus.

It was necessary to fulfil two requirements: to have an absorbent surface on which to drop the chloroform, and to permit the access of air which must be mingled with the anæsthetic vapors, and to prevent waste of the chloroform.

In England, where chloroform was first employed, several apparatus were devised by "Snow," "Sansom & Clover," etc. They all had disadvantages which prevented their general adoption. One of the more simple inhalers much used in Eng-

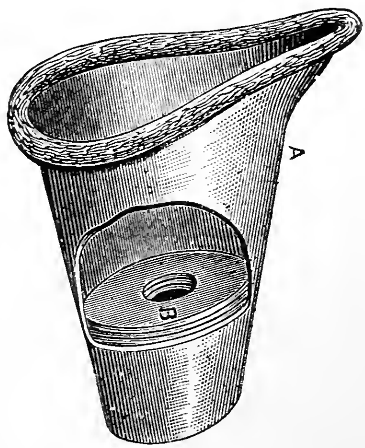
land consisted of a metallic box, with the margin hollowed out in the parts which correspond to the nose and chin of the patient, and of which the bottom and lower wall are pierced by a hole, permitting the entrance of the air.

An attachment in the shape of a horse-shoe, fastened to the upper wall in the interior of the apparatus, permits the firm adjustment of several rolls of linen, or two bundles of lint, on which the chloroform is dropped. The linen or lint is renewed each time the box is used, and by this means the apparatus is always in a state of perfect cleanliness.

Then they had "Skinner's" apparatus, a mask or wire frame over which was attached a piece of woollen stuff. The wire frame is placed over the nose and mouth of the patient, and on he exterior, or the woollen cover, is dropped a certain quantity of chloroform.

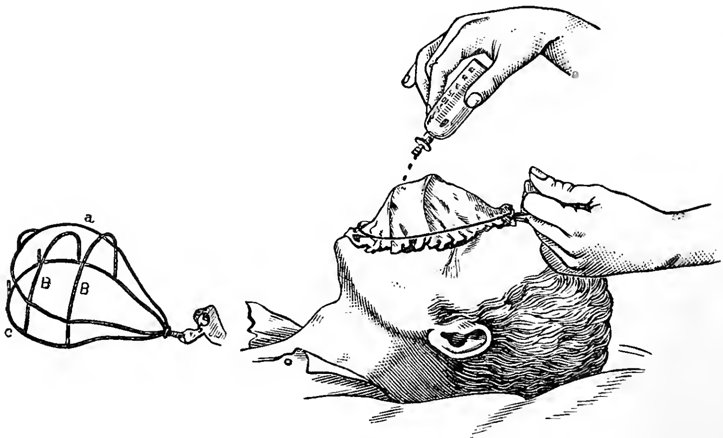
The apparatus of Raynard (of Toulon), Plate 45, is employed in France, especially in the navy. It is composed of a conical horn of pasteboard (A), pierced by a large opening at the top, and terminating in a mouth-piece which fits over the mouth and nose of the patient. The apparatus is lined on the inside with wool, at a certain distance from the top of the cone is a diaphragm (B), formed by several folds of wool, presenting in the centre a large aperture for the entrance of atmospheric air. It is upon this diaphragm that the chloroform is dropped or poured. The "anæsthetic horn" of Raynard has the disadvantage of leaving much to be desired in the way of cleanliness. Patients very often expectorate into the interior of the apparatus in that stage of anæsthesia which the French call "sputation," and it is difficult to cleanse it without destroying it.

PLATE 45.



At Plate 46 is seen the inhaler which is made by Charriere, of Paris. It is a wire frame, a, B, B and c, on which is fitted a covering of muslin which is held in place by wires a and c. There is a hook at the top which is held by the left hand, while in the right is the chloroform in a graduated bottle, and the chloroform is carefully dropped on the exterior of the flannel, not too rapidly, else there is produced a choking sensation. In neither of these inhalers should the chloroform be poured, else sudden stoppage of the respiration and suffocation of the pa-

PLATE 46.



Modification Inhaler of Skinner and Charriere, of Paris.

tient take place, or the liquid chloroform may pass into the larynx and cause death.

Clover's apparatus, which we have described in its original form under ether, was subsequently modified by Dr. Buxton.

Junker's apparatus is composed of a bottle having two tubes; it is enveloped in plated steel, but this envelope is pierced by a longitudinal opening, showing what is inside the bottle; this opening has marked upon it a graduated scale, which designates the quantity of the anæsthetic employed.

A hook allows the operator to suspend the apparatus from his clothing. One tube conveys to the bottom of the bottle the

air, which is forced there by a Richardson bellows. This air, after having mingled with the chloroform, passes out by an attachment and through the other tube to the mouth-piece, which is placed before the mouth and nose of the patient.

This mouth-piece, of hard rubber, has a valve of soft rubber which opens with expiration and closes with inspiration. A movable ring, placed at the point where the vapors arise, and pierced by two slits, corresponding to two openings of the same calibre in the attachment which prolongs the mouth-piece on this side, allows a greater or less quantity of pure air to reach the patient; this being mingled with the anæsthetic vapors, is propelled through the tube into the mouth-piece.

Half an ounce of chloroform is poured into the bottle through a funnel-shaped opening fixed in a screw top; air is then pumped through the chloroform, and in its passage it takes up the vapor. The foot bellows are fixed by straps, one of which slips over the toe, while the other receives the heel in the longer loop. When the foot presses lightly, the air in the bellows is forced through the tube into the bottle, thence through the other tube to the face-piece. The net-enclosed ball is for equalizing the stream of air and the avoidance of splashing. It is important not to put more than half an ounce of chloroform into the bottle at once, and not to pump the air spasmodically or too forcibly; otherwise pure chloroform may be drawn through the system of tubes into the face-piece. Even if this should not happen, a strong blast of chloroform-impregnated air is very unpleasant and deleterious if allowed to impinge upon the face. When the bottle has become nearly empty, the mill-headed stopper which closes the funnel is removed and more chloroform is added; thus the apparatus need never be unhooked from the administrator's coat and the top never unscrewed until the administration is over, when the bottle should be emptied and cleaned.

Dr. Buxton remarks: "A practical acquaintance with the imperfections of this inhaler has led to modifications of value, though it must not be supposed that by its use the patient is placed outside the range of possible danger."

The Scotch Method of Administering Chloroform.*

In July, 1892, the author was invited as one of the Committee on Anæsthetics of the British Medical Association, prior to the meeting at Nottingham, to be present at the clinics of Prof. Chiene and witness his method of administration of chloroform.

The following are his teachings in his syllabus of Lectures on Surgery—Chloroform :

A. Action of chloroform is (first) stimulant; (second) sedative.

- (a) Abolishes sensation.
- (b) Abolishes power of motion and reflex action.
- (c) *Stops respiration.*
- (d) *Stops heart's action.*
- (e) Kills patient.

B. Method of Administration—Towel *versus* Engine—Brains *versus* Valves.

1. Give all your attention.
2. Have your artery forceps ready.
3. Watch the breathing.
4. Watch patient's appearance.

   How do you know when the patient has had enough?

- (a) Insensibility of conjunctiva.
- (b) Muscular relaxation.
- (c) Local insensibility of part to be operated on.

C. Dangers.

- (a) Tongue falling back.
- (b) Glottis closing.
- (c) Fainting.
- (d) Vomiting.
- (e) Respiration and heart's action stopped.

D. Signs and treatment of these dangers.

- (a) Use the artery forceps to draw the tongue forward.
- (b) Lower the head, dash cold water on the face and chest, open windows and doors.

* Prof. John Chiene, University of Edinburgh, Scotland.

(c) Small doses of solution of cocaine, mustard plaster to the epigastrium, with lime-water and milk ; ice in small pieces.

(d) Artificial respiration ; elevate the upper part of the body.*

Drs. Wallace, Musselman, and his chief assistant, Dr. Emerson, all ready to assist or answer any questions. Number of students and medical men in attendance from 25 to 30. The chloroform was given to the care of one medical man, who had been at least *one month* under careful instruction in its use. The professor stated that the latter was simply to attend to that *duty and nothing else;* he was not even to restrain the patient. We noticed he had a woman as an assistant who, in the first case, attended to the pulse. We found that the operator watched the patient, so as to be sure everything was going on all right, as he considered this all important when performing the most difficult operation. He stated that, as a rule, it was most important only to watch the respiration. He also stated that there was no preparation of the patient (this was incorrectly reported in the *British Med. Journ.*), only the giving of a cup of beef-tea at 8 A.M. No special examination of the habits of the patient, his heart, lungs or kidneys. The chloroform was administered on a towel.

He performed four operations, none of them capital ones. Three of the cases did well under the chloroform, but in the fourth, for removal of anterior and posterior tibial nerve for pain in stump, the patient, who was a sailor, resisted the action of the chloroform, and it had to be removed twice, as he had an epileptiform convulsion with rigid chest, so that the younger assistants became alarmed, but not the Professor, who inquired of us what we did in such cases. We stated that we withdrew the chloroform entirely or gave ether. Ultimately he was able to perform the operation with considerable difficulty, as the man struggled violently, and required several assistants to control him. Prof. Chiene stated that such cases were termed

* Clinic of Professor John Chiene, University of Edinburgh, July 11, 1893.

by him alcoholists, sailors, as a rule, being very intemperate men. Such cases die in the hands of an ordinary practitioner who attempts to give chloroform alone without the required number of assistants (see case reported in Philadelphia *Med. News*, September 24, 1893).

The conclusion arrived at by the Hyderabad Commission on Anæsthetics, that chloroform kills by interference with respiration, is, no doubt, correct in the large majority of fatalities with this drug. When the commission, however, goes on to lay it down as a law in the administration of chloroform that the pulse need not be noted; that, indeed, noting it is actually harmful because it takes the anæsthetist's attention off the only thing worth watching, *i.e.*, the respiration, it goes too far. A large number of cases have of course been published in which chloroform, properly administered, has caused death by paralyzing the heart before it interfered with the process of respiration; but the teaching of the commission is so positive, and as many surgeons and anæsthetists think so dangerous, that all cases in which the heart was first affected should be made known.

Two such cases occurred at the Royal Victoria Hospital, Netley, lately (*London Lancet*, March 18, 1893). A skilled anæsthetist gave the chloroform from a "Krohne's" inhaler, than which there is no better apparatus for the purpose, and no struggling took place in either case. One was the case of a child aged three years, on whom the operation of needling was being performed for a congenital cataract; but as the operation was completed, the boy's face suddenly became pale, and the pulse was found to be imperceptible at the wrist and artery in the neck. At this time no cessation of the movements of the chest and abdominal walls took place, and air was heard to pass in and out of the lungs freely. Under the use of the interrupted current, friction and ether subcutaneously, the attack of syncope passed off. The second case was that of a man on whom the radical cure was being performed for an inguinal hernia. The patient took the chloroform freely until the sack of the hernia was twisted. When this was done, the man's face immediately blanched and the pulse became imperceptible, whilst

the movements of respiration continued vigorous and effective. Ether was injected, the head lowered, sponges wrung out of very hot water were applied over the heart and electricity to the neck. In about five minutes the pulse was again felt, and the man recovered. Had the rules laid down by the Hyderabad Commission for the administration of chloroform been carried out in these two cases; had the indications afforded by the observation of the pulse been disregarded, and the condition of the respiration alone noted, the chances are that the deaths of these patients would have had to be added to the already too long list of "deaths under chloroform."

Facts collected from the published statements of "The Lancet's Commission on Anæsthetics," March 15 and April 15, 1893, were to supplement the work of the second "Hyderabad Commission, who made all of its experiments on living animals." This last commission of the *Lancet* was a consideration of the results arrived at by clinical observations from all the larger hospitals of the Continent, as well as India, America and the Colonies.

Dr. Dudley Buxton gave the directions to the inquiry without any reference to his own views, in order to arrive at a continuous series of cases from 1847 (the date of the first employment of chloroform as an anæsthetic). Not only were the above sources of information used, but the records of Snow (1858) and those collected by the committee of the Royal Medical and Chirurgical Society, published in their transactions in 1864. (The report deals with all the anæsthetics, but chiefly chloroform.)

Classification of Cases.

The reports of the cases have been divided into the following classes: (1) Deaths under and apparently due to an anæsthetic; (2) Deaths under and remotely due to an anæsthetic; and (3) untoward cases, *i.e.*, cases in which some mishap occurred which was not followed by fatal results, but which was directly or remotely due to the anæsthetics employed.

Chloroform.

No age possesses immunity from death from anæsthetics. The greatest number of deaths in males appears to take place

between the ages of twenty-five and fifty. The fatalities of women are most frequent between the ages of twenty-one and forty-five.

Geographical Distributions of Fatalities.—Deaths are reported from all quarters of the globe. It was noticed that in Scotland, where chloroform is so widely and extensively employed, few reliable sources of information exist of the deaths which result from its exhibition.

Deaths do occur from chloroform in Scotland, notwithstanding a contrary belief has been assiduously promulgated. Such cases are not, however, often brought to light, since Coroners' inquests are almost unknown, and there is not the opportunity for newspaper publicity that occurs in England and America. A casual search of medical journals reveals the following chloroform casualties: Edinburgh Royal Infirmary (1878 to 1880), 3 deaths; Western Infirmary, Glasgow (1883 to 1886), 3 deaths; Royal Infirmary, Glasgow (1883 to 1885), 2 deaths; other parts of Scotland (1881 to 1883), 6 deaths. England, 110 deaths to 14 in Scotland during the same period. Population of England in 1880, 28,247,151; Scotland, 3,991,490. Ratio of deaths in England, 1 to 256,792; in Scotland, 1 to approximately 285,107; *vide* Dr. Alex. Wilson.

Methods Employed for Administering Chloroform.

1. Those in which no special form of inhaler was employed:
   - Chloroform poured on a handkerchief,
   - Chloroform poured on a towel,
   - Chloroform poured on a napkin,
   - Chloroform poured on a sponge,
   - Chloroform poured on lint,
   - Chloroform poured into an extemporized cone.

In fewer instances the process is described as having been conducted by the "open method," or chloroform given from a "cone of paper," "cloth," "compress" and so on. The recorded deaths resulting from chloroform being administered without an inhaler are rather more than double those occurring when an inhaler is used.

2. Deaths under chloroform when a specified apparatus (inhaler) was employed: the order of deaths during their use.

The following are the methods employed:

Inhalers (kind unspecified).

Skinner's inhaler (flannel mask stretched on a wire frame).

Snow's inhaler.

Junker's inhaler.

Clover's inhaler.

Esmarch's inhaler.

Metallic inhaler.

Grey's Hospital inhaler.

Morton's ether inhaler.

Weiss's apparatus.

Open method, chloroform "poured" on lint after the manner of "Syme," who taught that plenty of the drug should be used.

Open method, chloroform "dropped" on lint after the manner advocated by the dosmetric school, who teach that by dropping on lint almost safety is insured.

Causes Assigned for Death.

Of predisposing causes intemperance and wasting disease, the existence of emphysema, pathological conditions of the heart and bloodvessels are the most noted.

Immediate Causes of Death—Heart Failure and Respiratory Cessation.—Of the 506 cases recorded and which have come under the "Lancet Commission" the pulse is stated by the person who reports the death to have failed in first 143 instances, while in 59 records the respiration is described as being primarily stopped; in 46 it is mentioned that the respiration and circulation (as judged by the pulse) ceased simultaneously; whilst in 36 the pulse probably, it is asserted, failed first, in 4 the respiration probably failed first, and in 12 they probably failed simultaneously; in 211 cases no record was given as to which failed first.

Of the cases collected by the committee of the Royal Medical and Chirurgical Society, out of 83 cases, 26 are given in which the pulse failed first, 4 in which respiration failed first,

11 in which respiration and circulation failed simultaneously, 9 in which the pulse, probably, failed first, 2 in which the respiration, probably, failed first, and 7 in which they, probably, failed simultaneously, while 24 cases had no records of these points.

A very careful consideration of all the records which have been brought under the notice of the commission would seem to favor the conclusion that in the large majority of cases, the symptoms and phenomena detailed bear out the view that death was due to syncope *in so far as the clinical evidence would decide, one way or the other.*

In drawing up this summary the greatest difficulty has arisen in many cases from the looseness and inadequacy of the published records. It has been necessary in some instances to place apparently similar cases under different headings, when the causes assigned for death have been different, although the lessons have been similar. Thus in one case death is attributed by the narrator to syncope, although *it is stated that food was found in the wind-pipe*, which, it may be presumed, caused respiratory trouble, leading, it may be, to syncope as an ultimate result.

No attempt has been made to tabulate information as to the quantity of chloroform used or its quality.

Repeated Inhalation.

Of the cases examined 11 males who had died under chloroform had taken it safely once before, 11 females and 13 males more than once.

Purified Chloroform—Anæsthetic and Physiological Action.

When one per cent. of chloroform is mixed with three to five per cent. of atmospheric air, it becomes charged with it, and in this form it is usually employed as an anæsthetic.

The amount of vapor which can be taken up (held in solution) by the air of the atmosphere, varies with the elastic tension of the chloroform vapor at different temperatures. Thus, at 40° F., a small quantity of chloroform would evaporate into air ; at

130° F., so much would volatilize as to give rise to an almost pure chloroform vapor. In the following table, taken from Snow's "Anæsthetics," the amount of chloroform in vapor is shown in 100 cubic inches of saturated mixture of air and chloroform at different temperatures:

Degrees F.	Air per cent.	Vapor per cent.
40	94	6
45	93	7
50	92	8
55	90	10
60	88	12
65	85	15
70	81	19
75	78	22
80	74	26
85	70	30
90	65	35

One grain of chloroform in 100 cubic inches of air produces the second degree of narcosis, but never carries chloroformization further. This corresponds to a proportion of 1 part by measure of chloroform in 16,285 parts blood, or 0.0000614, the proportion by weight. Two grains in each 100 cubic inches of air, or $\frac{1}{28}$ saturation (unity being saturation), produces the fourth stage of narcosis, or 0.0001228 the proportion by weight.

Any proportion above two grains in the hundred causes interference with respiration; three grains in the hundred seems about the ratio which renders respiration impossible. Three grains represent 2.3 cubic inches vapor, and as air at 100° F. can take up 43.3 per cent. of its volume, the blood must contain from $\frac{1}{18}$ to $\frac{1}{19}$ of the proportion it is capable of absorbing when the respiratory centres are poisoned.

Snow found further, that calculating the weight of the blood as thirty pounds, twelve minims of chloroform in the circulation produce narcosis of the second degree; eighteen minims, the third degree (surgical anæsthesia); twenty-four deep narcosis (fourth stage), and thirty-six should paralyze the medullary centres. In practice more is needed, because a certain propor-

tion evaporates from the tracheal and bronchial surfaces, and is carried out in expiration. If twelve minims be evaporated into a bladder, and inhaled to and fro, no more air being allowed than can be blown from the lungs, narcosis of the second degree actually results. Now, taking thirty-six minims as a lethal dose, the following considerations, upon which Snow strongly insisted, explain how easily this quantity may enter the circulation if the administrator be not perpetually upon his guard against over dosage; eighteen minims represent the amount absorbed to produce surgical narcosis; this amount might be absorbed by the use of thirty-six minims, the remaining eighteen minims being exhaled as above mentioned. These thirty-six minims represent 37.5 cubic inches of vapor, which, at 60° F., would require 257 cubic inches of air. The 300 cubic inches thus formed would be inspired in twelve respiratory acts (25 cubic inches being the amount of tidal air). Now, if a vapor of this strength were continuously inhaled, the residual and complemental air would become saturated, and as about 250 cubic inches represent the air in the lungs, this amount would at 60° F. contain the vapor of thirty minims. Assuming only half this quantity to be absorbed, that is fifteen minims, we should then have 18 + 15, or thirty-three minims in the blood, an amount almost, if not quite, enough to paralyze the respiratory centre. These points being held in remembrance will explain many cases of chloroform death ascribed to "idiosyncrasy," or the "fatty heart," which stand inexpert chloroformists in such good stead. Death from chloroform does not, however, always result from respiratory paralysis.

Death occurs from heart-failure, cardiac syncope or asphyxia, from too large a quantity of chloroform being employed; also, owing to the closure of the glottis, or paralysis of laryngeal muscles; also, respiratory failure, or absorption into the blood and nerve structures, producing entire alteration of them.

What has experimentation determined definitely in regard to the action of chloroform? The action of chloroform on the brain is, first, congestion; but when there is complete anæsthesia, it produces decided anæmia in man and animals. The muscular excitement of the second stage is, according to experi-

ments, purely physical; and there is, during the production of anæsthesia, a steady lowering of reflex action.

Chloroform at first induces contraction, and afterwards much the same pupillary phenomena are seen during the action of drugs which affect the cerebro-spinal system, even in those, which, in the first instance, produce myosis. In such, if the action of the drug be pushed, a stage is arrived at when the function of the respiratory and cardiac centres is so seriously compromised that the pupils become widely dilated and fixed. This may be illustrated by the action of three drugs—opium, chloroform and alcohol. In opium coma, the pupil is always firmly contracted, while in alcohol coma, we can distinguish it from opium, if we pull the beard or hair, as this act will cause temporary dilatation.

In chloroform narcosis, the same pupillary phenomena are observed during the extreme stages. From personal observations, extending over several hundred carefully recorded cases, it is seen that the pupils are in a very variable state during the preliminary periods, much too variable to permit any rule being formulated regarding them. When, however, reflex action is abolished, except in the cardiac and respiratory centres, the pupils become contracted and fixed. (Dr. MacEwen, of Glasgow, stated to us, that young operators frequently make the serious mistake of judging that the patient is ready for an operation merely from the test of touching the cornea with impunity, when an examination of the opposite eye will convince him that he has produced by the close application of the chloroform of the cloth, nothing more than a local anæsthesia, confined to one eye.)

Anæsthesia from chloroform is divided into five stages, as follows:

In the first stage—from commencement of inhalation to impairment of consciousness—fulness of the head, ringing, buzzing in the ear, palpitation of the heart are sometimes felt; there is also some diminution of common sensation.

In the second stage the mental powers are impaired, although not suspended. The patient remains passive, as if sleeping, or occasionally makes a voluntary movement. Sometimes laugh-

ing, singing, talking are indulged in during this stage. Snow believed that dreaming occurs at this time, and then only. Towards the close the patient becomes restive ; he attempts to remove the face-piece or towel, for he is conscious of being inconvenienced by the vapor, but not of the necessity for remaining passive. Common sensation is much blunted, so that patients submit without expostulation to painful manipulation. This degree of narcotism is sufficient for obstetric practice and the after-stage of prolonged operations. As a rule, struggles or expressions of pain which show themselves at the time are not subsequently remembered.

In the third stage all voluntary movements are lost. The conjunctival vessels become full, the muscles rigid, and struggles, even epileptiform convulsions, may supervene. As the stage advances the muscles relax: Inarticulate jabbering and mouthing occur. Although really insensitive to pain, the patient may flinch or even cry out. Later in this stage, all reflex acts are abolished, the conjunctival and nasal receding last. The patella jerk also persists late, while under deep anæsthesia the ankle-joint phenomenon appears.

In the fourth stage breathing is stertorous, the pupils dilated, and the muscles completely relaxed and flaccid. In this stage the patient is profoundly unconscious, and is drifting into danger. Such deep narcosis is seldom needed, save for the reduction of old-standing dislocations, etc.

The fifth stage is the interval which, following the fourth degree of narcosis, intervenes between the respiratory embarrassment and total cessation of breathing. Even after dyspnœa has passed into apnœa, the heart continues to beat for a brief while. This stage marks the period when chloroform tension in the blood is great enough to paralyze the respiratory centres in the medulla oblongata.

The third stage may be regarded as the safety zone of complete chloroform narcosis. But if anæsthesia be pushed beyond this stage, wide dilatation of the pupils ensues, indicating a suspension of function in the cardiac and respiratory centres. This is a most critical condition, though one by no means necessarily fatal, as by lowering the head and raising the floor of the

table, and by promptly carrying out artificial respiration, even while feeble respiratory efforts are being made by the patient, the danger may be, and frequently has been, averted. Given a person free from organic lesion of the nerve centres, heart or lungs, in whom, during chloroform narcosis, stable mydriasis suddenly occurs as a result of the action of chloroform on the respiratory centres, the patient ought to recover if artificial respiration, coupled with the lowering of the head, be promptly resorted to, and the former efficiently carried out. It is interesting to note, in such cases, the marked effect produced by elevating the foot of the table, so as suddenly to place the patient's head and thorax at a very low level, the pupils becoming quickly contracted. In this connection, however, it ought to be borne in mind that one of the earliest indications of a return of reflex action is vomiting, which, as a rule, is accompanied by dilated pupils, the result of cerebral anæmia.

In cases where the functions of the cerebro-spinal system, especially of the cardiac and respiratory centres, have already been enfeebled (by organic lesion or otherwise), chloroform acts more powerfully, a few whiffs sufficing to induce complete insensibility, and the administration of an ordinary dose giving rise to an alarming state, which only prompt measures can prevent from becoming fatal. In such cases the pupils very readily pass into wide dilatation, with a very small amount of chloroform.

When the function of the brain is suspended by want of oxygenated blood, the pupils are widely dilated and fixed.

This may be seen in cases of asphyxia, either by poisonous gases or arising from mechanical causes. It was once observed by Dr. MacEwen in two men, who had all but succumbed by inhaling coal-gas, emanating from a broken gas-pipe in their bed-room, and it is also seen in cases of hanging.

The Pupil as a Guide in Giving Chloroform.

Neilson considers the pupil a reliable indication of a patient's condition, under chloroform anæsthesia, and concludes from his experiments as follows:

"1. The effect produced by chloroform on the pupil is, at first,

dilatation, varying in degree and duration, then contraction as the narcosis becomes profound, and dilatation again when the sensibility is returning. If the administration be still continued, with the pupil strongly contracted and motionless, the pupil will also dilate, but in this case more suddenly and completely, and will be coincident with a state from which it will be difficult or impossible to resuscitate the patient. This latter is the dilatation of asphyxia.

"2. So long as the pupil dilates in response to excitation by pinching, etc., the patient is not sufficiently narcotized for the operation to be proceeded with unless the latter is slight and does not require complete anæsthesia.

"3. When the pupil becomes strongly contracted and immobile, no more chloroform should be given until it begins to dilate again. If, then, further anæsthesia be required, a little more chloroform should be given until the pupil again contracts.

"4. The occurrence of sickness causes dilatation similar to, but more sudden than, that which happens when sensibility is returning, and the efforts of vomiting have the effect of arousing the patient."

During the first half-minute of the inhalation of chloroform, there is a progressive lowering of the arterial pressure. Chloroform, if injected into the jugular vein, instantly arrests the heart's action.

Chloroform produces contraction of the red blood disks; if, however, air be admitted to blood containing chloroform, the red corpuscles rapidly disappear, dissolving in the serum, out of which, after a time, hæmatin crystallizes. One authority states that after anæsthesia bile-acids appear in the blood; and it has been found that the oxygen of the blood undergoes an increase during anæsthesia. During the action of chloroform the temperature falls, the circulation is retarded, and the skin gives off less insensible perspiration.

According to the recent experiments of Ranke, which we have before referred to and repeated on several small animals (and this is also the view of the late Claude Bernard), the nature of the action of chloroform upon the nerve cells is slight coagulation; but if the animal was killed with the chloroform,

there was hardening of the nerve trunks and entire change, in which evident coagulation of the albuminoid tissues took place. If chloroform was mixed with blood not exposed to the air, there is no change except contraction, either shown under the microscope or by spectrum analysis; this we have repeatedly determined in the frog, rabbit, pigeon, etc.

Toxicological Effects.

Chloroform is the most potent and agreeable anæsthetic, but the most dangerous, and is the one in which death may occur at any and every stage by inhalation. Chloroform kills so suddenly that neither skill nor care can always guard against a fatal result. Another disadvantage of chloroform is its high boiling-point, requiring a great amount of heat and vital force to exterminate it from the body, so that it is probably never eliminated entirely by the lungs, but only with the aid of all excreting organs. Any deficiency or derangement of the body which may consequently lead to such suppression or elimination, causes the nervous system to be overwhelmed with consequent inactivity. Almost all anæsthetics may kill during the first stage by asphyxia; the air may be very highly charged—even saturated—with the agents; so much so, that owing to its pungency it cannot be breathed, and if forced upon the patient, stifles and suffocates him in exactly the same manner as would sulphur burned under his nostrils; death would thus occur without much having entered the body.

Owing to the danger which accompanies its use, chloroform should only be administered when other anæsthetics are not available; or under the especial circumstance that without it the shock of the operation might kill the patient. In railroad accidents, and military surgery, it becomes at times absolutely necessary; and in the holds of ships, especially those of iron, where the temperature is very high, it is resorted to on account of its rapidity of action, smallness of quantity required, cheapness, small bulk in transportation, and the less risk of explosion and ignition. In obstetrics, chloroform is used with comparative safety to the mother, although a few deaths have been reported; but from our observations taken, in carefully-

watched cases, it is apt to be fatal to the infant. Conclusions have been drawn, that in long and instrumental labors, ether, or bromide of ethyl, although not so pleasant, are much safer to the child.

The symptoms which usually occur as precursors of death from chloroform are a sudden paleness or lividity of the countenance, shallow breathing, stertor, loss of, or a quick and weak pulse, tossing about of the patient, delirium, convulsions, or coma.

Chloroform should never be administered in a sitting posture, nor should a patient rise suddenly when under its influence.

What is the chief danger to be apprehended when chloroform has been used, and how do we prevent fatal symptoms, as closure of the glottis, fainting, failure of the pulse, or respiratory syncope?

Stop the administration of the chloroform, lower the head to an angle of forty degrees, and elevate the feet above the level of the body, and remove the mucus or blood that may collect in the mouth during the operation. Draw out the tongue, and retain it out by a ligature, Ketch forceps, or dry towel, and elevate the jaw, and above all use artificial respiration, keeping it up for at least one hour if necessary. Administer from ten to twenty drops of nitrite of amyl, if the face is pale, but not, if flushed; drop from a bottle on a piece of cloth and hold it to the nose and mouth. If the patient make no effort to breathe, force it up the nostrils by means of a small hand-spray compressing apparatus, and expand the chest by manipulation with the elbows to the side, and compress the chest. This should be continued until the heart acts. Flagellation with towel wrung out of ice water is very useful, but do not chill the patient. If there is still increased narcosis, employ hypodermic injections of water of ammonia (containing five per cent. of ammonia gas) to the quantity of a drachm or two, or solution of sulphate of atropia. But depend chiefly on lowering the head, and artificial respiration long continued. Give the patient plenty of fresh air by opening the windows; if cold, cover with blankets. Apply a galvanic or Faradaic current during the artificial respiration, one electrode to the base of the neck and the other to

the epigastric region, on a line with the diaphragm, but not in the region of the heart or solar plexus. Let the assistants or nurses rub the extremities briskly, and use even slight blows on the neck, and side of the chest, but not on the stomach.

It is not safe to continue an operation immediately on a patient's recovery from the excessive action of anæsthetics, but to wait until respiration has been energetically restored; otherwise, a new and generally fatal asphyxia may be produced. It is well to remember that anæmia of the brain is secondary to the cessation of the heart's action, and that to restore vitality to the brain requires that the heart's action be restored. For this purpose, as we have stated before, there is nothing better than lowering the head and artificial respiration, and the use of it is to be continued, not only for a few moments, but for hours; indeed, recoveries have occurred after the use of the Faradaic current and artificial respiration for one hour.

It has been clearly proven that in cardiac and respiratory failure, the pneumogastric nerve retains its excitability in chloroform poisoning, and it is, therefore, extremely dangerous to apply electricity to the neck in this condition. (See the experiments and observations of Doctors Hare and Martin on the phrenic nerve.)

A New Way of Raising the Epiglottis.

Dr. Howard, of London, has endeavored to prove that traction of the tongue cannot, as is supposed, raise the glottis, but that the only way by which it can be certainly raised is by extension of the head and neck, whereby its elevation is instant and complete. The patient is brought to the edge of the bed, or the chest is elevated, so that the head may swing free, and with one hand under the chin, and the other on the vertex, steadily, but firmly, carry the head backward and downward, until the most possible extension of the head and neck is obtained.

In reference to the above paragraph, we addressed a letter to Dr. H. A. Hare, knowing that he, in conjunction with Dr. Martin, had made experiments on the subject. He sent us the

following article, which is of so much importance that we have published it entire for the benefit of those who may have an urgent respiratory crisis in anæsthetization.

The Treatment of Arrested Respiration in Anæsthesia.*

"In a paper read before the Medical Society of London, Dr. Benjamin Howard maintains the following propositions:

"1. The epiglottis falls backward in apnœa, and closes the glottis; the first thing in order and importance is the elevation of the epiglottis.

"2. Traction upon the tongue, however, and whatever the force employed, does not and cannot raise the epiglottis, as supposed.

"3. The epiglottis can only be raised by extension of the head and neck.

"4. The full effect of extension can only be secured, with certainty, by making the extension complete, as directed.

"5. The method of making extension is as follows: 'Having, by bringing the patient to the edge of the table or bed, or by elevation of the chest, provided that the head may swing quite free, with one hand under the chin and the other on the vertex, steadily but firmly carry the head backward and downward; the neck will share the motion, which must be continued till the utmost possible extension of both head and neck are obtained. Sometimes a slight elevation and extension of the chin will at once check stertor, or irregularity of breathing; but understand, the extension, which can in no case do harm, should always be rather more than appears necessary. It should never be forgotten, however, that the full effect of extension, as above described, can be secured with certainty only by making the extension complete, as directed.'

* By Edward Martin, M.D., Instructor in Surgery, University of Pennsylvania; Surgeon to the Philadelphia Hospital and to the Howard Hospital; and H. A. Hare, M.D, Demonstrator of Therapeutics, and Instructor in Physical Diagnosis, in the Medical Department, and in Physiology, in the Biological Department, University of Pennsylvania.

"These propositions are, in some respects, so contrary to the daily experience of surgeons and anæsthetizers, and, if well founded, are of such supreme importance in cases of suspended animation, that we have conducted a series of experiments designed to test, in so far as this is possible, by working upon the dead body, the validity of Howard's conclusions.

"Limiting our inquiry to those cases of threatened death which occur from respiratory obstruction, during the administration of an anæsthetic, we must first endeavor to discover the mechanical cause which is principally operative in producing such obstructions. We presume that by apnœa, Howard means, not a condition of suspended respiratory efforts through hyperoxidation of the blood, which is the true significance of the term, but cessation of respiratory movement. We cannot believe the epiglottis is chiefly at fault as an obstructive agent, because, in the vast majority of cases, the air-passage is at once made free by drawing the tongue forward; since tip-traction has no effect upon the epiglottis, as stated by Howard and confirmed by our own observations, this manipulation could not relieve the breathing were the epiglottis the cause of the difficulty. The effect of traction upon the tip of the tongue is to draw this organ free from the soft palate and the post-pharyngeal wall; it is the tongue, then, fallen back upon the posterior wall of the pharynx, which is the most common obstructing cause; consequently, the tongue should receive the most immediate consideration. We do not for a moment deny the possibility of respiratory difficulty being caused by the epiglottis alone, though experimentally the inward passage of air was very little influenced by any position of the epiglottis, provided the tongue was carried well forward: we would insist, however, upon the position of the tongue as a matter of prime importance. Considering next the effect of tongue-traction upon the epiglottis, we are not prepared fully to indorse Howard's statement. Tip-traction moves the epiglottis not at all; this we have confirmed by many trials, both in the living and in the dead subject; but if a tenaculum is fixed in the dorsum of the tongue two and a half inches back from the tip, traction at once draws the base of the tongue, and the epiglottis with it,

far forward, so that the air-passage is absolutely free from the larynx to the mouth. Traction can then be so applied to the tongue that the epiglottis is raised and the air-way made absolutely free, and we have devised an instrument by which this may be accomplished without the laceration attendant on the use of hooks or forceps.

"Is extension of the head and neck the only method of raising the epiglottis? Again we are compelled to take exception to Howard's statement. As detailed in our experiments, the epiglottis can be raised by traction upon the dorsum of the tongue by pressing the greater cornua of the hyoid bone forward by the action of gravity in the abdominal decubitus, and most thoroughly by flexing the neck and extending the head upon the neck. That Howard's position accomplishes mechanically all that he claims for it, we freely grant. The way in which the soft, collapsed structures straighten under his manipulation, the tongue riding forward and the epiglottis springing erect, is most striking; and we are convinced that the admirable mechanical explanation he gives for this effect is correct. Howard states:

"'. . . . by extension of the head and neck, carried to the utmost completeness, the backward-fallen tongue, the velum palati and uvula, are all simultaneously shifted from the air-way, and the entire pharynx is enlarged throughout as follows: *a.* The tongue, the dorsum of which before fell by gravitation upon the then horizontal posterior wall of the pharynx, falls upon the now horizontal arch of the palate. *b.* The velum palati, by means of the great tension of the palato-pharyngeal muscles, is pulled away from the posterior wall of the pharynx, the entire membrane being stretched tightly forward and downward, behind part of the dorsum of the tongue, forming a partition which helps to shut the tongue out of the pharynx and into the mouth, where it belongs, and with part of the dorsum forms the anterior wall of a new post-oral air-way, thus created and maintained. *c.* The pharynx, anteriorly, is stretched far forward by the extremely tense sterno-thyroidei muscles acting through the thyroid cartilage, by the genio-hyoidei and mylo-hyoidei muscles, acting through the os hyoidei.

The base of the tongue and the velum palati are shifted forward in the manner already described, the posterior nares being shifted, by the extension of the head, by its occipito-vertebral articulation, about sixty degrees. Posteriorly, the wall of the pharynx is shifted back its whole length by the extension of the cervical vertebræ upon each other, in all about thirty degrees, extension being particularly great just opposite the glottis. Thus the upper air-way, which before was a tortuous, angular, flaccid canal—barely, and if at all uncertainly permeable—is made an enlarged, firm, but slightly curved tube, free throughout from the glottis to the nares.'

"With all this, except the backward shifting of the posterior wall of the pharynx by extension, we are fully in accord. We cannot, however, concede that his practical deduction from these facts is a step in the right direction. With the head and neck in extreme extension, the soft palate is strapped over the dorsum of the tongue, the mouth is closed from the pharynx and the entrance of air to the lungs depends absolutely upon the condition of the nostrils. Can it be considered an additional safeguard—an improved method—to substitute for the roomy mouth an air-way, but just sufficient at the best, subject to an infinite variety of obstructions, varying in size from hour to hour, in many persons absolutely, and permanently occluded? Certainly no American rhinologist would answer in the affirmative. Hypertrophies, polypoid growths and vegetations are not the rare exception. The slightest congestion is frequently sufficient to block patulous nares. A nostril which will admit the little finger of the surgeon, when the patient is standing, may become completely closed when the head is placed on a level with the body. The recumbent or dependent position, the irritating effect of ether upon the mucous membranes, cephalic congestion due to insufficient oxidation, all combine to render the nostrils unsafe—in fact, absolutely impracticable—as the sole passage of communication between the lungs and the external air. We cannot believe that recourse to this method, in cases of suspended animation under anæsthetics, could be followed by favorable results; if the tongue were drawn forward it would certainly provide ample air-way, the passage from the

pharynx to the mouth being opened by this manipulation. One of the great advantages of this method, however, as claimed by Howard, is that the necessity for traction upon the tongue is entirely done away with. If the necessity for drawing forward the tongue is not done away with we cannot see that Howard's method offers any material advantage over that ordinarily practiced in this city.

"Our experiments show that extension of the head carried so far that the base-line (Reid's) makes an angle of somewhat more than fifty degrees to the plane of the bed, or table, raises the tongue and epiglottis so entirely clear of the posterior pharynx that there is ample air-way; the soft palate, too, lies free of the post-pharyngeal wall, but is not drawn closely across the dorsum of the tongue, thus allowing respiration to take place through the mouth. If, in the course of an anæsthetization, there is respiratory difficulty, the method which obtains here is as follows: The chin is immediately pressed forward by the fingers placed behind the rami of the lower jaw; at the same time, and by the same manipulation, the head is extended, the pillow, if any has been used, being removed; if there is still apparent obstruction the tongue is now drawn forward. With this manipulation, except in case of foreign body or abnormality of structure, the air-passage from the mouth to the larynx is absolutely free. Hereafter we may modify this method, so placing the pillow that the neck is flexed as far forward as possible, then extending the head upon the neck, as we find that this gives us wide dilatation, the posterior pharyngeal wall representing the arc of a circle, from the concavity of which extension of the head draws forward the tongue, epiglottis and larynx. In the method as detailed above it rarely occurs that the tongue has to be drawn forward.

"Finally, we cannot grant that Howard is justified in believing, of the hundred cases of death due to the administration of an anæsthetic, that in each case the epiglottis was in all probability unraised, and continued unraised until death was complete. The appearance of the parts after death cannot be taken as indicative of their relative position during life—when inspiratory efforts are still taking place, when the rigor mortis has not

made the surrounding muscles more rigid than the epiglottis. Again, the very traction upon the tongue, as usually exerted, extends the head sufficiently to carry the epiglottis free of the post-pharyngeal wall. Finally, where inspiratory efforts are being made, there is no difficulty in determining whether or not air is entering the chest; the noise of its passage through the mouth and throat, the respiratory sounds, are sufficiently characteristic of its free entrance; while sinking in of the intercostal spaces, epigastrium, and suprasternal region, during an inspiratory effort, are absolutely diagnostic of obstruction. These signs, though not so patent, are still sufficiently clear in artificial respiration, and if the cause of death were even in the majority of cases simply obstructive, this condition of obstruction would unquestionably have been recognized and remedied, if not by position certainly by tracheotomy or intubation.

"The results of our examinations, made upon several cadavers, are as follows:

"By chipping away the basilar process of the occipital bone the naso-pharynx is exposed.

"Subject in the dorsal decubitus, head midway between flexion and extension, eyes looking directly upward, Reid's base-line (from the lower border of the orbit through the bony meatus) at right angles to the plane of the table.

"The tongue lies in close contact with the posterior wall of the pharynx, only the tip of the epiglottis being visible. The soft palate and the dorsum of the tongue shut the mouth from the pharynx. The air-passage is completely obstructed by the tongue and epiglottis.

"By means of a tenaculum passed through its tip, the tongue is seized and drawn forward as far as possible. The body of the tongue is drawn clear of the post-pharyngeal wall and the soft palate; the hyoid bone, the base of the tongue and the epiglottis are not at all influenced.

"The tenaculum is now fixed two and a half inches from the tip; traction draws both the base of the tongue and the epiglottis well forward.

"The fingers are passed behind the angles of the lower jaw, and the latter is pressed forward; this elevates the epiglottis

and the base of the tongue about a quarter of an inch from the post-pharyngeal wall. Extending the head so that the base-line makes an angle of forty-five degrees with the plane of the table, draws the base of the tongue and the hyoid bone far forward, this motion being at the same time imparted to the epiglottis, so that the latter stands upright, and is separated from the posterior wall of the pharynx by an interval of about an inch. By tightly closing the jaw, the antero-posterior space is still further increased.

"The body is drawn to the end of the table, so that the head hangs free; the latter is now extended until the base-line is parallel to the plane of the table; the antero-posterior space between epiglottis and pharynx is slightly greater than that which obtains from moderate extension. At the same time the tongue drops toward the roof of the mouth, the soft palate is put upon the stretch, and the mouth cavity is shut out from that of the pharynx.

"Placing the head so that the base-line is perpendicular to the plane of the table again produces complete closure of the pharynx, owing to the tongue and epiglottis falling directly backward.

"Placing the fingers upon the posterior cornua of the hyoid bone, and pressing the latter directly forward, carries the epiglottis and tongue about one-half inch forward and entirely free of the post-pharyngeal wall.

"With the head moderately extended, and the jaw pushed forward, an effort is made to crowd the tongue and epiglottis against the post-pharyngeal wall; this is found to be impossible.

"Flexing the neck by lifting the head forward (keeping the base-line perpendicular to the plane of the table) separates the post-pharynx from the epiglottis and the base of the tongue by about one-half an inch. Extending the head upon the neck, the neck being still flexed, produces a yet wider separation, the antero-posterior diameter of the breathing space being somewhat more than one inch.

"Placing the body in the position of abdominal decubitus, the base-line being perpendicular to the plane of the table, the

hyoid bone, base of the tongue and epiglottis all fall forward, leaving an interval of about half an inch between the epiglottis and post-pharyngeal wall.

"On elevating the shoulders, by seizing them and lifting them directly upward, this space is increased to fully an inch; at the same time the arytenoid cartilages are drawn backward, exposing the glottis throughout its whole extent.

"Bringing the body to the end of the table and letting the head droop forward (still in abdominal decubitus), thus flexing the neck to its full capacity, then extending the head at the occipito-atloid articulation, exposes the larynx more completely than any of the previous postures or manipulations.

"Conclusions.—The epiglottis may prevent free entrance of air to the lungs, even though the tongue is pulled forward. Any means which accomplishes the anterior projection of the hyoid bone, immediately and infallibly raises the epiglottis and the base of the tongue.

"The hyoid bone may be made to project anteriorly by direct pressure upon its cornua, by direct pressure or traction applied to the dorsum of the tongue, behind the anterior half-arches of the palate, by the action of gravity in the abdominal decubitus, or by extension of the head upon the neck.

"Extension of the head upon the neck, carried as far as forty-five degrees, produces practically as patulous a condition of the air-way as forced and extreme extension. At the same time this moderate extension usually leaves sufficient room between the palate and the dorsum of the tongue for breathing to continue through the mouth.

"In forced extension of the head and neck, the entrance of air into the lungs depends upon the sufficiency of the nasal passages.

"Flexion of the neck, with extension of the head upon the neck, does away with the epiglottis as an obstructing factor as completely as any other posture. This is best accomplished by supporting the head upon a high pillow, then pulling it directly backward by the hand placed under the chin, so that the weight of the head falls upon the occiput rather than upon the back of the neck.

"Therefore, in case of an urgent respiratory crisis in anæsthetization, we would direct that the index fingers placed behind the greater cornua of the hyoid bone, and the middle fingers resting upon the angles of the lower jaw, both these structures be pressed directly forward, the same force also serving to extend the head upon the neck. If obstruction to breathing still persists, the tongue should be at once drawn or pushed forward by force, exerted upon its dorsum posterior, to the anterior half-arches.

"No force, unless directly applied to the tongue itself, is sufficient to infallibly prevent this organ from acting as an obstructing factor. No manipulation yet devised can, in every case, take the place of direct action.

"The tongue may act either in conjunction with the pharyngeal walls or with the palate, in preventing free entrance of air. If the position of moderate extension and direct traction or pressure upon the tongue fail to remove the obstruction to breathing, intubation or bronchotomy remains as the last resort."

Apparatus of Martin and Hare for the Treatment of Cases of Arrested Respiration, and their Conclusions in Injury or Destruction of the Phrenic Nerve.

"The apparatus which we devised for use in a case where the body is too large to permit of the operator swinging it, as in the man and dog, under similar circumstances to those named, was constructed as follows, and consisted of a board supported on an upright of equal width and rounded edge, the horizontal plank resting by means of a groove on its under surface upon the convexity of the vertical support. To this horizontal board is then bound the subject, and by a see-sawing movement the body is rapidly changed, so that at one moment the head is down at an angle of forty-five degrees, and at the next moment is correspondingly raised, while the feet fall. In this way the weight of the abdominal contents is thrown against the diaphragm as the head is lowered, and the air in the thorax is thereby driven out. On the other hand, if the head is rap-

idly raised and the feet fall, the abdominal contents drop into the pelvic space, dragging the diaphragm after them, and thereby producing inspiration.

"In order at the same time to extend the chest, as the abdominal contents sagged downwards, we were forced to invent a simple apparatus which, by means of cords, raised the arms above the head at the moment that the feet approached the floor."

Conclusions.

"1st. Injury or destruction of the phrenic nerves is not followed by death, as has heretofore been taught.

"2d. That in injuries involving the diaphragmatic movements it is important that the patient shall not be anæsthetized, as under those circumstances the absence of voluntary aid in respiration may be attended by fatal results.

"3d. The seriousness of phrenic injury is in direct ratio to the dependence of the respirations of the normal animal on the diaphragm, and to the ability of the chest walls to make compensatory movement.

"4th. The symptoms resulting from interference with the functions of the phrenic nerves are as definite and characteristic as those following interference with any other motor nerve. There will always be well-marked increase in the scope of the thoracic excursions, and distinct reversal of the movements of the belly, *i.e.*, the belly will retract on inspiration.

"5th. Fear of injury to one or both phrenic nerves need not prevent operations about the neck and upper portion of the chest, provided that due caution be exercised, that the patient is but slightly under the influence of the anæsthetic at the time, that danger of injury to these nerves is most imminent. Infancy, however, constitutes an exception to this rule; only absolute and pressing necessity for operation would afford justification for such a procedure in early life.

"6th. The real effects of section of the phrenic nerves being known, it follows that the nerve is subject to the same operation in case of injury as are other nerves of the body, such as suture.

"7th. The presence of the abdominal viscera are necessary for the normal movements of the diaphragm.

"8th. The abdominal contents may alone be used for the production of artificial respiration, but while they are always to be employed to this end their use should never be allowed to displace those movements which are directed to the chest. Both should be used together if possible.

"9th. In cases of injury to the phrenic nerves support should be given to the belly walls, to prevent movement of the same, and to brace and steady the paralyzed diaphragm, care being taken that the floating ribs are free.

"10th. The method of Sylvester drives more air through the lungs than any other single method, but its best results are not gained unless the feet be drawn down as the arms are extended.

"11th. The volume of respired air after section of the phrenic nerves is temporarily decreased until the thorax compensates for the loss of the diaphragm.

"12th. Oxygen gas is a valuable agent in the treatment of persons suffering from coal-gas poisoning.

"13th. Oxygen gas aids very materially in bridging over the respiratory crisis occurring after injury to the phrenic nerves.

"14th. In life-saving stations, mines, police stations, or other points to which asphyxiated persons may be brought for resuscitation, in hospital clinics, or in private houses, where ether or chloroform is given, oxygen in appropriate form for immediate administration should be provided. The accoucheur also will find in this gas a valuable adjunct in the treatment of cases of suspended animation in the newly born. Very small cylinders, containing forty gallons of the compressed gas, are easily carried and require a small amount of space.

"15th. The electrical methods now employed for the resuscitation of persons who have ceased breathing are dangerous and unjustifiable."

On the Influence of Climate and Heat on the Use of Chloroform.—The following extracts from letters of distinguished surgeons in the South will show the influence of climate on the use of chloroform :

Dr. Langdon B. Edwards, editor of the *Virginia Medical*

Monthly, October 21, 1878, states that it is one of the most peculiar facts he has ever known in medical practice—the difference of experience in Europe and in the North with chloroform and ether as compared with that of the South—the high rate of mortality in the North and the low rate in the South. Anæsthetics are used for more trivial affections and surgical operations in the South than in the North, and, of course, for obstetrical cases, etc. Even during the war, when the Southerners were not using Squibb's ether, or a chloroform having the reputation of such purity, their preference was for chloroform, although of home manufacture. Had a case that was fatal occurred from its use in any of the small cities or towns it would have become wide-spread news.

The operation of insertion of a needle into the heart might excite the quiescent organ to action, while again it might cause a feebly beating heart, that would perhaps recover if given a chance, to become hopelessly inco-ordinated.

Abstract as to the Dangers and Treatment of Fatal Symptoms from the Use of Chloroform as an Anæsthetic.

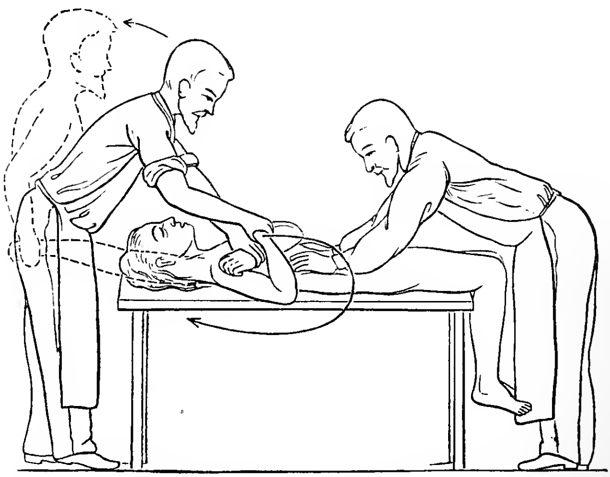
1st. Failure of the heart, which may occur at all stages. 2d. From reflex inhibition by terror. 3d. By the irritation of the vapor. 4th. From chloroform idiosyncrasy.

Symptoms.—Feeble, fluttering pulse; pallor; grayness or blueness of the face, ears and fingers, or a sudden interruption or complete stoppage of the heart action.

Treatment.—Careful examination of the heart, lungs and kidneys, and forbidding chloroform in cases of atheromatous disease of the vessels, which can be felt; fatty degeneration of the heart, with great pallor of skin and feebleness of action; aortic or advanced mitral disease, which must be determined by the history and stethoscope. If the symptoms given in the first part are present, the chloroform must at once be removed, the head and body inverted, first removing all foreign bodies from the mouth; let limbs be elevated in women and blankets

well wrapped around them, or the body inverted over the knee of an assistant. When, as occasionally happens, the anæsthetizer is single-handed, the raising of a patient by the feet is practically out of the question, except to one of unusual strength. Any one of good physique is able, however, to accomplish the same thing quite readily by placing his hands beneath the patient's hips, and raising them until the leg can be slipped beneath, and the patient then rests upon his knee, the foot being upon the bed. The head and shoulders can now be

PLATE 47.



Sylvester's Method of Artificial Respiration.

swung off the bed, and at need the patient, from the head to knees, brought into a vertical position. If the tongue has fallen back, draw it forward, and keep it held firmly out of the mouth. If the breathing is not relieved, an assistant employs Sylvester's method of artificial respiration as follows: The operator stands behind the patient and grasps the arms near the axillæ; he first presses the arms into the sides, so as to compress the thorax and expel air, whilst an assistant makes gentle pressure upon the abdomen. Next, he firmly draws the arms away from the sides, everting them, and lifting the patient as the arms be-

come about 45° beyond the head. Finally, he carries the arms back to a line with the head. He pauses to allow air to rush freely into the lungs, and then brings the arms down to the sides as before. This process is repeated twelve or sixteen times in a minute.

Forced respiration is stated to be an advance upon artificial respiration, and will save human life where the latter will fail. According to Dr. Geo. E. Fell, of Buffalo, N. Y. (*Journal American Medical Association*, October, 1889), the apparatus consists of a bellows to supply a steady stream of air, which passes through an air-heating apparatus; an air-valve which controls the ingress of air to the lungs, and is connected by an elastic tube and tracheotomy tube in the neck and trachea of the patient.

The Epiglottis in Chloroform Accidents.

Dr. A. E. Prince, in *N. Y. Med. Jour.*, says: "As an illustration of the uncertain knowledge which exists upon the subject, may be cited the belief that drawing out the tongue will raise the epiglottis, and thus open the air-way to the lungs. This belief exists in the minds of a large proportion of the profession, and the procedure is employed and recommended by many leading surgeons. By way of correcting the error, reference is here made to a demonstration, by Benjamin Howard, before the Royal College of Surgeons, England, the conclusions drawn from which are: First, contrary to the universal belief, traction of the tongue cannot raise the epiglottis; second, by sufficient extension of the head and neck, whether by volition, instinct, reflex action or by effort of another, whether in the healthy, in the dying or in the dead, the epiglottis is instantly and beyond prevention made completely erect; third, by a complete extension of the head and neck the tongue and velum, as respiratory obstructions, are removed simultaneously with the epiglottis, and without a moment's delay the entire air-way may be straightened and made free throughout by the nearest person."

We copy this article because it differs from the well received idea.

Resuscitation by Anal Dilatation.

Dr. L. C. Grosvenor, of Chicago, in the *Journal of Orificial Surgery*, August, 1893, gives an unique as well as amusing account of three cases of resuscitation by means of forcible dilatation of the anal orifice. The first case was a man dying from an over-dose of morphine. The second was the arousing of an infant born asphyxiated, while the third was that of infantile eclampsia. His *modus operandi* is to grease the thumbs of either hand and proceed to dilate the sphincter. He thinks this process acts as a direct stimulant through the sympathetic, and believes it might be successfully applied in resuscitating the drowned where the spark of life is not quite extinct.

Brunton on Chloroform.

After the reading of Dr. Wood's paper on Anæsthesia, Dr. T. Lauder Brunton,* in introducing the discussion of the subject of chloroform narcosis to the Berlin Congress, spoke as follows: "Does danger to life during chloroform narcosis arise from failure of the heart or failure of the respiration, and how is such danger to be averted?" After tracing the nature of the early investigations for the discovery of the toxic effects of chloroform, he concluded: "I grant at once that chloroform is a protoplastic poison. I have rendered the muscles of an animal as stiff as a piece of wood by injecting it into the artery of a lamb. I have stopped the pulsations of an animal's heart by blowing chloroform vapor directly into the lungs. But what I wish to maintain is, that notwithstanding all this, when chloroform vapor is inhaled in the usual way by inspiratory efforts of the patient himself, it does not stop the heart, but first acts upon the respiratory centre, and, by stopping the breathing, prevents a quantity of chloroform, sufficient to stop the heart, from reaching that organ."

This we consider false reasoning on the part of this distinguished experimenter, and is the old doctrine of Syme and the

* Abridged from his paper, The Lancet, August 16, 1890, p. 351.

Edinburgh School. Listen to him when he informs us of the time between the respiration and its action on the heart: "We may say, then, that the time of grace *is only half a minute*, and if the administrator's attention should be so distracted as to allow this half a minute to elapse after the respiration has ceased, the patient will probably die."

It is evident, then, that constant attention to the respiration is required; and, indeed, this was the great lesson taught us by our experiments. When chloroform was inhaled with free admixture of air, it usually produced a fall of blood-pressure to some extent, but the administration of chloroform may be continued for a long time without much further fall, provided, always, that plenty of air be given with it. If, however, chloroform vapor be given with a deficient quantity of air, the fall of blood-pressure is very rapid, the cardiac pulsations become slow and irregular, and shortly cease altogether.

This irregularity is well shown in the tracing of the Glasgow committee, from which they draw these conclusions, that chloroform depresses the heart, and does so irregularly, and in an unforeseen manner. The tracing is evidently one of slow pulse due to irritation of the vagus. In numerous experimental attempts to irritate the vagus, Dr. Brunton did not succeed in reproducing the tracings, but on simply closing the animal's mouth and nostrils, or closing the opening of the tracheal canula when one had been introduced, he was able at once to reproduce the tracing. He was able to produce such curves both when the animal was thoroughly under chloroform and when it was completely out of chloroform.

He found, that with pressure upon the chest, death occurred very rapidly from the administration of chloroform. This is a very important hint, both to the assistants and the operator also, to avoid tight clothing or the corset in the care of ladies; and this is applicable in the use of all anæsthetics. Examination of both heart and the urine is of vital importance.

The question, he states, is still unsettled, and cannot be finally settled either from a purely clinical or the purely experimental side. Both must be worked up together, and to this

end the London *Lancet* has sent out a circular asking for information regarding all cases of death from chloroform. When all the deaths from chloroform have been completely tabulated, their causes may be interpreted by the light of experiments.

An abstract of the first of these we produce, and this from a Scotch surgeon of eminence:

"Statistics show that the fatalities attributed to chloroform cannot be explained by the condition of the patient's previous health, the severity of the operation, or the result of the autopsy."

More Recent Views in Regard to the Action of Anæsthetics.

Conclusions of a report of the action of chloroform, with a criticism of the second Hyderabad Commission, by W. H. Gaskill, M.D., F.R.S., Lecturer on Physiology in the University of Cambridge, and L. E. Shore, M.D., Demonstrator of Physiology in the University of Cambridge.*

The principle upon which Lawrie administers chloroform may be summed up in a single sentence: "Never, at any moment of the administration of chloroform, administer it in so concentrated a form as to cause irregularity of respiration, and cease the administration as soon as complete anæsthesia has been induced." The danger, then, of chloroform administration consists (1) of causing a serious fall of blood-pressure, owing to weakening the heart from too great a percentage of chloroform in the air, which, in its turn, causes failure of respiration; and (2) cessation of respiration after long administration, although given with plenty of air, after anæsthesia has been established.

A more recent criticism by Dr. Brunton, of London, states, as a result of his physiological experiments, that respiration is affected, causing asphyxial condition of the blood, the combined action of chloroform and asphyxia affecting the heart.

The Action of Chloroform.—Dr. Lauder Brunton, after going over the experiments of Drs. Gaskell, Shore and others, reaches

* British Medical Journal, February 4, 1893.

the following conclusions: (1) That Drs. Gaskell and Shore are mistaken in regard to the fall in blood-pressure produced by chloroform as the most important question connected with its action. (2) That the conclusions of the Hyderabad Commission are entirely unaffected by their criticism, which is directed to two things: (a) the effect of chloroform injected into the jugular vein and (b) the pulse tracings obtained during chloroform narcosis. In regard to (a), the error into which "Gaskell and Shore" suppose the commission to have fallen was suspected by the commission, and, as they believe, was avoided. In regard to (b), the criticism of Drs. Gaskell and Shore, it is not directed against the conclusions of the commission, but against the comments made in the course of describing individual experiments. The tracings thus criticised were not considered as satisfactory evidence by the commission, and were consequently not employed by them as a basis for their conclusions. (3) That they have devised a most ingenious plan of experiment by cross circulation and have obtained many interesting results. While these experiments may afford much valuable information, they are not entirely free from fallacy, as they were not performed on animals under chloroform influence alone, but with either morphine or chloral. (4) That they entirely confirm the conclusions of the Hyderabad Commission, that the chief danger from chloroform is the concurrence of asphyxia, and that the most important practical point is attention to respiration, as maintained by Syme and Lister.

We feel, like Dr. Wood,* that Dr. Brunton has in his recent publication given away the whole case of the Hyderabad Commission, as follows:

"As every one knows, the Hyderabad Commission, the great supporter of the exclusiveness of respiratory death, derived most of its authority from the presence on the Board of Lauder Brunton, of London, who in a recent publication says: 'If we drive chloroform into the trachea, or air very heavily loaded with chloroform vapor into the lungs by artificial respiration, it will be absorbed in sufficient quantities to paralyze the heart.' This

* Anæsthesia, by Dr. H. C. Wood.

is a practical giving away of the whole case of the Hyderabad Commission, at least as I have understood it, and as I believe it to have been understood by the general profession. However this may be, it is a confession that the chloroform death is not of necessity due to asphyxia, so that it must be admitted, first, that both ether and chloroform may kill the man or the lower mammal either by arrest of respiration or by syncope; second, that syncopal death from chloroform is not common, though it does occur in the lower animals, but is not rare in man; third, that the difference between ether and chloroform, so far as the mode of death is concerned, is that that form of death (syncopal) which is common under the influence of chloroform is rare under the influence of ether."

Resuscitations by Lingual Tractions.*

Members of the Royal Navy having frequently, when at sea, to consider the best means to resuscitate the drowning, and our coast guards having to rescue people by means of the Board of Trade's rocket apparatus and coast ladder appliance, it struck me that a few observations might be of use to the readers of the *United Service Gazette*, with the view of dispelling the hitherto erroneous views which have been too commonly accepted anent resuscitation.

Dr. J. V. Laborde, Professor of Physiology at the Paris Faculty of Medicine, according to his own accounts, has founded a French school of enthusiastic inquirers and experimenters who, in extraordinary and apparently hopeless cases—cases where it was alleged that all other methods of artificial respiration and the like had failed—nevertheless resuscitated many still-born infants and adults apparently dead. In his recently published treatise, he and his followers declare that already, up to March 20, 1894, they had saved sixty-three lives, which, according to their own statements, were all rescued by Laborde's methods of repeated, long-continued, persistent lingual tractions, or pulling the tongue outwards, downwards and forwards

* By J. Lawrence Hamilton, M.R.C.S. Reprinted from the United Service Gazette, August 11, 1894.

at the rate of from fifteen to twenty or more tractions to the minute, movements that are accredited with having special powers to excite contractions of the diaphragm, to promote the suspended powers of the respiratory reflex. Laborde suggests that death is absolute where repeated lingual tractions fail to restore animation.

In the accidental asphyxia or syncope noticed in experimenting upon animals, especially on dogs, above all where anæsthetics had been administered, in French laboratories presided over by Dr. Laborde, the first operation was to seize the tip of the tongue. Thereby not only were the laryngeal-pharyngeal tracts opened, but repeated rhythmical retractions as a rule resulted in the return of respiration, which followed close upon a series of loud hiccoughs.

At first these noisy hiccoughs responded, as it were, passively to the artificial lingual tractions, but later the respiration became automatic and spontaneous.

In the Royal Medico-Chirurgical *Transactions*, vol. lxxii., Dr. Bowles has shown that, in apparent death from drowning, in the supine or horizontal position, the paralyzed tongue, by letting its base drop backwards, thereby blocks up the pharynx.

Although it hooks up the dropped base of the tongue, nevertheless Laborde's method fails to remove the frothy water, often muco-sanguineous—with or without mud, sand and the like—from the water-logged lungs, and perhaps also the abnormal contents of the stomach and œsophagus, which may also be more or less filled with somewhat similar foreign materials.

In every case, first put the patient in a suitable position to allow of the immediate escape of these fluids from his chest, in which procedure pulling the dropped base of the tongue forwards is pressingly urgent.

In a much condensed form, Dr. Laborde's *Tractions Rhythmées de la Langue* might be worth translating into and publishing in English; but then only if the well-known up-to-date work of others, including that of Dr. Alexander Morison, were added to Dr. Laborde's investigations.

John Hunter's 1776 historical paper on resuscitation, by means of his specially constructed bellows inflated with air or with oxygen, is not even mentioned by Dr. Laborde!

His book ignores references or even allusions to the best literature and past experimental research on the resuscitation of men and animals, which greatly detracts from the value of Dr. Laborde's far too one-sided observations and vague conclusions.

Some of Dr. Laborde's cases of alleged resuscitations of still-born children would doubtless have spontaneously recovered without medical assistance.

Dr. Champney's elaborate experiments, published in 1887, on the artificial respirations of still-born children, could be advantageously studied by Professor Laborde, as well as Taylor and Stevenson's (1894) *Deaths from Secondary Causes after Successful Resuscitations.*

In all cases of attempted resuscitation and of first aid in ambulance drills to restore suspended animation, added to the usual methods of resuscitation, Laborde's method should be tried, though to rely on it solely, as advocated and implied by Dr. Laborde, would be indeed foolish and frequently fatal.

Rhythmic Traction of the Tongue in Accidents. The Asphyxia from Chloroformization.*

We come now to speak of chloroformic intoxication, to which belongs the primitive accident of cardiac syncope or that of respiration, or both occurring at the same time, which so often mark the beginning of the administration of chloroform in surgical anæsthetization, or which constitute one of the episodes during the anæsthesia.

It is precisely, as we can doubtless recall, in these conditions, that we have experimentally determined the application of this procedure of rhythmic traction of the tongue in treating chloroformic accidents, and these are, really, its point of departure

*Les Tractions Rythmées de la Langue. Par I. V. Laborde, Directeur des Travaux Physiologiques à la Faculté, Membre de l'Académie de Médecine. Paris, 1894. Translation.

and its origin. It is by the aid of systematic lingual traction that we have conquered, in our laboratory, all conditions of snycope or accidental asphyxia following chloroformic or chloral anæsthesia. No doubt the same results would have followed the same treatment in surgical operations.

We have received in this connection another fact (of which there will soon be mention) from Dr. Filiget, hospital surgeon—the account of a case in his own practice which, in regard to the procedure of which it treats, presents a real interest. (See on this subject an interesting observation of Dr. Gigard, of the Côte St. André, Isère, published in the *Med. Tribune*, No. 12, 1894.)

In August, 1883, M. Filiget, substituting for M. Lariboisurè, had occasion to operate on a patient—Jules Broe—for cancer of the superior left maxillary. He practiced preparatory tracheotomy and administered ether by the trachea. In the course of the operation a respiratory syncope supervened, with apparent death. Traction of the tongue was immediately resorted to and recalled the patient to life.

I am convinced, in fact, and have already remarked in former communications, that simple traction of the tongue beyond the mouth, such as has been resorted to by surgeons for a long time, with the end in view of freeing the back part of the throat, as one might say the speaking tongue, from being drawn back by the excitation and contraction caused by chloroform—that this traction can, I say—and has in certain cases done so—restore respiration. This is demonstrated in the preceding case of Dr. Filiget's, but it would not suffice in advanced cases of asphyxia following chloroformization with apparent death. It is necessary to add, reiterated and persistent rhythmic tractions constitute the true and systemic procedure in question.

The majority of surgeons who are acquainted with this method do not fail now to use this treatment at the first evidence of danger from chloroformization, and we know that in a certain number of cases, of which it is to be wished that the operators themselves might publish them, the gravest accidents and probably more or less imminent death habitually occurring in such conditions have been averted.

We give below two cases of this nature, of which one has been published in a medical journal and the other comes from one of our colleagues.

"An operation was performed two days since at the Hospital of St. Andrew of Bordeaux, by Dr. Dennea, upon a patient suffering from neoplasm of the larynx, the anæsthetic used being chloroform, with a centigramme of morphia, where this procedure of Dr. Laborde's succeeded, although all respiration was suspended, and the patient blue, almost black, from asphyxia. Although the canula had been placed in the trachea, respiration did not return. Rhythmic tractions of the tongue were made persistently, respiration returning at first irregularly but later perfectly."

Professor E. Masse added to his account of the case the following remarks:

"Dr. Laborde has certainly given us here a most beautifu result. It cannot be contested that he was successful in restoring respiration in this subject in a state of asphyxia from the combined action of chloroform and of stenosis of the larynx. This method, while not excluding all others, gives us another arm upon which to lean, and which seems to give naturally the best results in accidents from the use of chloroform.

"Dr. Laborde has often used this treatment during operations upon animals. Every one knows that complete asphyxia frequently occurs in dogs under chloroformic inhalation. After ten minutes' traction of the tongue he has often restored animals when they were in a state of complete asphyxiation. He gives the following observations of his friend and colleague, Dr. Meniere, of the National Institute of Deaf Mutes:

"'Apparent Death Following Chloroformization.—Recalled to life of rhythmic traction of the tongue. Your remarkable work upon rhythmic traction of the tongue in the case of apparent death has interested me greatly. Since your presentation to the Academy of your observations upon this subject are multiplying, permit me to offer one of which I know personally.

"'Observation XIII.—Last month one of my little patients of the Dispensary Furtado-Hine presented an external

caries of the mastoid, caused by an osteo-periostitis following an old chronic otorrhœa. Operation was plainly indicated. It was necessary to make a complete curettage of the region. One of my residents, who was quite *au fait* in anæsthetic practice, gave the chloroform. The child slept easily, nothing particular occurring to note.

"'The operation, of eight minutes, was finished, and I was about to pass a drain when I noticed that the patient was not breathing. No beating of the heart, no pulse, no respiration. The face was cadaverous in color.

"'Immediately the child was put upon the table with his head hanging over, and one of my internes resorted at once to artificial respiration. At the same time I seized the tongue with pincers, and made in continued fashion rhythmic traction of the tongue, as you have described. It was six minutes before the first physiological inspiration was evident. We continued the tractions and artificial respiration during a moment longer, and the child was saved.

"'I am convinced that the tractions rendered me here a veritable service.

"'I can only repeat, *apropos* of this, what I said in one of my first communications to the Academy on this subject. (November 22, 1892.)

"'In the case of chloroformic accidents by respiratory or cardiac syncope, or of both together, the procedure of the tongue can be, as in experimental chloroformization, the most powerful means and the quickest of resuscitation, not only by putting the tongue out to free the back part of the mouth, but of making with it repeated and rhythmic tractions until the appearance of a hiccough, the precursor of returning respiration.'"

Note.—As we go to press, we received from one of our colleagues in Algeria, Dr. Mosiman, Ex-Medicia Major in the Army and Chief of Clinics of Val-de-Grace, one of the most remarkable cases of recalling to life by lingual traction made upon a young man operated for hæmorrhoids, he being in a state of apparent death from chloroformization. "I am persuaded," he declares, "that had I not known this procedure, I should have lost my patient."

Dr. Perrier, Surgeon to the Lariboisiere Hospital, also gives a case in his practice equally successful under like circumstances.

On the Influence of Chloroform in Producing Tissue Changes, Such as Fatty Degeneration of the Heart, of the Diaphragm and Other Striated Muscles, and also of the Parenchyma of the Liver and Kidneys.

As early as 1850, Casper stated that chloroform produced chronic poisoning, and later Liman affirmed that after prolonged chloroformization patients pass into an abnormal condition which continues for days, even for weeks, and finally ends in death. These views were confirmed by R. Unger,* who reports as the result of his investigations, pursued since 1883, that the inhalation of chloroform produces fatty degeneration of the heart, of the diaghragm and other striated muscles, and also of the parenchyma of the liver and kidneys.

He was also of the opinion that protracted inhalation of chloroform vapor, during tedious operations, may thus produce a state of weakness, in which a *second inhalation may prove fatal*, though the patient apparently tolerates the *first inhalation without dangerous symptoms.* For this reason he opposes the use of chloroform in normal child-birth.

These results were confirmed by Dr. Strassman,† in his experiment on dogs, who found that the first organ to be affected was the liver, then the heart, and after that the other viscera. He states that the nature of the morbid change was not fatty degeneration, but fatty infiltration.

The actual cause of death in fatal cases appeared to be the cardiac affection, as in all such a very marked degree of change was found in the heart. In non-fatal cases the morbid change was found to have disappeared in a few weeks' time. When morphine was given previously to chloroform less of the latter

* R. Unger (5 Cent. für Chir., Artificial Anæsthesia, Turnbull, 3d Edit., p. 462, 1890).

† Turnbull, Manual of Anæsthetics, 3d Edit., p. 490.

was required, and consequently the changes produced were not so considerable as when the ordinary amount was given.

Animals suffering from hunger, loss of blood, etc., were especially predisposed to the morbid changes due to the chloroform.

These researches were further confirmed by experiments on animals by Ostertag, Kast and Mester. A more important departure was made by Dr. Eugene Fraenkil, by a careful study upon four human subjects, dying after prolonged chloroformization, who found a wide-spread necrotic degeneration, associated with a disposition of much pigment in all parts of the body, but especially affecting the *heart*, *muscle* and the *epithelium of the kidney.*

In summing up these various experiments, Prof. H. C. Wood and Dr. W. S. Carter* state, in further confirmation of the powerful influence of chloroform on nutrition—there are also the observations of Salkowski—that marked increase in the output of nitrogenous waste is caused by the administration of the drug to dogs; of Kast and Mester, that there is a marked increase in the elimination of chlorine and nitrogen produced by the anæsthetic; and of Petruschcy, that after death from chloroform the intercellular juices become rapidly acid.

Ostertag in his conclusions differs somewhat from Unger in believing that the fatty degeneration is, in part, due to the destruction of the red-corpuscles by the chloroform. As, however, he also believes that the destruction of the protoplasm is, in part, affected by the direct influence of the chloroform, the difference between his views and those of Unger is not vital. Moreover, whatever of scientific interest may attach to the method in which chloroform produces its ravages to the surgeon, the method is of little practical importance, the vital fact being that chloroform itself directly or indirectly destroys the living protoplasm in almost all proportions of the human body.

Perils of Chloroform Administrations in Dental Operations.

If a patient is not thoroughly under the influence of chloroform any irritation of the fifth nerve would produce slowing of

* Copied from original Essay. MSS., 1896.

the heart's action, and finally stoppage through the pneumogastric nerve. This has been clearly shown by experiments on rabbits. This may account for the deaths in the dental chair from operations on teeth. Chloroform is the most powerful of the anæsthetics; too much caution cannot be written and taught, that the heart power is most seriously reduced by its action, and that it is incapable of supplying the brain properly unless the patient is in the recumbent posture.

The researches of Richardson, Rabuteau, and others, have shown that the physiological action of chloroform increases in intensity and danger as the number of carbon atoms increase, so that while wood spirit (methyl alcohol), with but a single atom of carbon, is transient and slight in its effects, those of fusel oil (pentyl alcohol), which has five atoms of carbon, are prolonged and severe.

Chloroform Given Improperly.

The fact that teeth have been extracted under chloroform, and without injury to the patient, does not justify its use for this purpose. The surgeon that would seat a patient in a chair and give chloroform to amputate a finger, or even open an abscess, would be guilty of negligence short of criminality; but much more culpable is he who performs so simple an operation as the extracting a tooth in this position. We are too much inclined to excuse blunders, hoping that the blunderers have been taught a salutary lesson, which, however, is of no benefit to the person who has come to an untimely death. There should be more care in dealing with the ills which flesh is heir to, so that the patient survives the treatment. It is a well-recognized rule, that a patient should never immediately assume the upright posture, especially after the use of chloroform, whose chief depressing influence is upon the heart, as by placing the head low, the blood returns to the brain and heart, and the patient is safe. This well-known method of Nelaton has had to be employed in several instances in the same case, and thus saved the life of the patient. The heart of every patient should be examined before a systemic anæsthetic is employed, and to a patient with fatty heart, chloroform should never be given.

It is now beginning to be observed by the profession generally that there is something of very material importance in the *manner* in which anæsthetics are administered; that there is an anæsthetic art deserving careful study and application in practice. It is not an uncommon observation to see the administration of the anæsthetic intrusted without discrimination to an assistant who holds the paper cone carelessly over the patient's face, and watches, in the meantime, the various steps of the operation. Can it be wondered that, in a process involving such essential physiological functions, dangerous and alarming symptoms arise and escape notice under these circumstances? Unquestionably, the administration of the anæsthetic should receive the undivided attention, during an operation, of one who has, by study and training, acquired a knowledge of the proper method of administering the agent, and who, in danger, will be prepared to act promptly and intelligently in his efforts at restoration.

The Employment of Nitrite of Amyl.

Being desirous of knowing some of the more obscure points in regard to the way in which the nitrite had been used in a case of death from chloroform, we wrote to Dr. Taylor, addressing the following questions: Did the nitrite of amyl produce a flushing of the face, action of the heart, and difficult breathing when you employed it yourself? Did you use a tube to force it up the nostrils when the breathing had ceased? How many drops were employed? Was it in capsules or dropped from a bottle?

The doctor kindly replied as follows:

RICHMOND, May 31, 1878.

DOCTOR TURNBULL:

Dear Sir: Your letter dated May 20th found me out of the city for a few days. I am very glad to answer your inquiries. You say that "Professor Nelaton's method will sometimes fail, especially when morphia has been used with the chloroform." No morphia was given at the time with the chloroform. It

was during the sickness that large quantities had been administered. In regard to the amyl used, it was made by Squibb, and was, I think, pure. I am sorry I cannot find a sample of it to send you for examination. It was dropped from a bottle upon a handkerchief. The number of drops was not ascertained. No tube was introduced into the nose.

Very respectfully, etc.,

HUGH M. TAYLOR.*

The number of deaths from chloroform which have occurred up to date will be seen in our tables. It will be seen by a glance how and why deaths from chloroform have occurred, and how unsatisfactorily, in most of the cases, the facts connected with the circumstances have been reported.

In our last edition we have entered into detail concerning such deaths (with table) from chloroform. In this later edition we have detailed but a few.

* We do not think the doctor quite justified in the use of so powerful an anæsthetic in so trifling an operation as external perineal urethrotomy. The nitrite of amyl was not employed until the patient had become unable to inhale it. His conclusions† are not the most recent, as a careful reading of our table of deaths from it will show. It gives but little warning before it kills the patient.

† See full account of case, p. 426, 3d edition of Manual.

CHAPTER IX.

Table of Deaths from Chloroform, and Ether, since the Hyderabad Commissions, with Conclusions—From 1888 to 1895 inclusive.

We live in an age of wonderful progress; in nothing is this better proven than in the multiplication of new and valuable books. The works of even one year becoming almost obsolete, new editions and new works taking their place. This is also the case with original experiments and investigations, crowding out the old. Nothing is lacking in either men or money. Two of the most munificent works of this kind have recently been undertaken in even far-off India, the sum of ten thousand dollars having been spent by the Nizam of Hyderabad in experiments on anæsthetics alone. This large sum was given owing to the devoted efforts of Surgeon-Major Lawrie, of the Army of India, who is a great admirer and believer in the opinions held by the late Professors Syme and Simpson, of the Edinburgh School, in regard to chloroform.

There were two Commissions, one held in 1888, in which 141 dogs were killed by chloroform inhalation, and the symptoms and results of careful post-mortems were made. The chief conclusions which were arrived at were "that it is impossible for chloroform vapor to kill dogs by acting primarily on the heart, and this holds good, no matter in what doses or in what manner the poisoning is induced." These conclusions having been received with doubt by many physiologists, and more especially by the editors of the *London Lancet*, led to a Second Commission, and Dr. Lauder Brunton, a well-known author and physiologist, was added to the Commission. The conclusions of the Second Commission were published January 19, 1890. About six hundred animals, chiefly dogs, were employed in the investigations.

The experiments of the committee were designed to show the effect upon the blood-pressure, heart and respiration of the

inhalation of chloroform, ether and the A. C. E. mixture, administered in various ways and under varying conditions. The subjects of the Commission were five in number:

1. To test the suitability and safety of chloroform as an anæsthetic. The experiments with ether and the A. C. E. mixture were instituted principally for the sake of comparison with chloroform on certain points, and it is not pretended that they afford a complete exposition of the action of those agents on the system.

2. The effect of pushing the above-named anæsthetics (a) to a dangerous degree, and more especially until the respiration ceases; (b) until death results.

3. The modifications in the effects of these anæsthetics which result from (a) asphyxia in varying degrees and produced by various means (b) from the use of drugs, such as morphine, atropine, physostigmine and others.

4. The reality or otherwise of the alleged liability during ordinary chloroform administration to the occurrence of primary or secondary syncope or stoppage of the heart, brought about either by shock or through fatty or weak heart, or by hæmorrhage, or by changes in the position of the body. To investigate these points, in the first place a large number of operations, which are reported to be especially dangerous in reference to shock, were performed in every stage of anæsthesia, and numerous experiments were also made to show the effect of direct irritation of the vagus. Secondly, a number of animals were dosed with phosphorus before they were experimented on. This caused the weakening of the heart by fatty degeneration of its fibres, but at the same time other complicated changes in the whole of the organs of the body, not met with in the condition known as fatty heart in human beings. On the other hand, there are conditions often found in the fatty heart, such as changes of the coronary vessels, which were not produced by the phosphorus.

5. The effects of the anæsthetics above mentioned upon different animals, more especially upon monkeys, as the nearest approach to human beings.

In brief, the practical conclusions arrived at as to the effects

of chloroform, "that in every instance the respiration stopped before the heart," and all that was necessary for safety was to attend to that alone. Soon after the publication of the views thus expressed, several practical chloroformists gave their opinion, founded on professional experience, that chloroform was by no means to be considered safe by simply attending to the respiration, and that the heart still played a most important part in the deaths, as may be seen from the numerous deaths from syncope given in our tables.

With this view I have made a most careful collection of all the deaths both from chloroform and ether, from every available source, assisted by several friends. These deaths have been arranged in a tabular form, giving the name, age, history, nature of operation, anæsthesia used, amount used, apparatus employed, posture, how long under influence, whether heart or respiration stopped first, means to resuscitate, how long continued, post-mortem, cause of death and references, except in a few instances.

The result of examinations and analysis of the table will be found on pages following.

The exceedingly small number of deaths from ether demonstrates its great safety; still, as it will and does kill (and we notice that the feeble and persons suffering from malignant disease are more apt to be its victims, see Nos. 10, 11 and 18), we would advise its use as an anæsthetic and a full study and knowledge of the best modes of using it, which we judge is not the case in Europe.

It is true that "chloroform acts more rapidly than ether, is pleasanter to take, causes less congestion of blood in the veins, is much more portable and handy." The last two qualities render it preferable in certain classes of operations, *e.g.*, in those on the eye and in military or travelling establishments. On a campaign it would be impossible to find room to carry ether or time to use it.

Again, ether cannot be used in hot climates or in close proximity to artificial light; nor is it suitable in certain conditions of the lungs, because ether is more apt to cause suffocation than chloroform, which is given with a much greater admixture of

air. Against these advantages on the side of chloroform ether has only one, which, however, is sufficient to outweigh them all —it is safer.

With regard to occasional unexplained deaths under chloroform, it must be remembered that they occur also under ether, though not so frequently, and used to occur in a similar way before the use of anæsthetics at all. Dr. Brunton also had several accidental deaths, but in every case "the usual chloroformist was absent, and no one was attending to the chloroform"— a most significant statement. How often might the same be said (with a stress on the word "attending") in our hospital practice. The Hyderabad conclusions really imply a tremendous indictment against the administrators of chloroform—nothing less than that of causing death by carelessness. Unhappily, no one familiar with the administration of anæsthetics can doubt that there is some ground for this. How else account for the widely differing records of different administrators? Every surgeon knows that with good chloroformists he is perfectly confident and easy, with others the reverse. The last word has by no means been said upon this controversy; but if we may venture a prophecy, it is that the answer to the question, "Is chloroform safe?" will eventually be, "That depends on who gives it."

We have proofs in opposition to the experiments and statements of the Commission, that chloroform may arrest the heart before arrest of respiration. In one experiment breathing continued two minutes after the heart had ceased to act.

THE PULSE DURING CHLOROFORM ANÆSTHESIA.—A case in point, in which chloroform so depressed the pulse that ether had to be resorted to. The British Medical Committee (1890) on anæsthetics, after examining the kymographic tracings taken by the Hyderabad Commission, cannot agree with the Hyderabad Commission in holding that there is no danger to the heart during the administration of chloroform. Both committees have found that death occurs by failure of respiration in the great majority of cases, and that chloroform causes a gradual fall of blood pressure, which in itself is a source of danger. Both have also observed that in addition to this gradual fall

there may be sudden and unexpected falls, with slowing of the heart; but as to the explanation of these falls they differ. The Hyderabad Commission holds that these falls, during which life is in jeopardy, are caused by asphyxia, while the British Medical Association Committee affirm that they are due to failure of the heart, due to a specific action of the chloroform upon the organs (from which ether is free). The general conclusion of the British Medical Association Committee is, that while recognizing the great value of the work done by the Hyderabad Commission, and more especially as aided by Dr. Lauder Brunton, they consider that the commission attach too much importance to the most common mode of death from chloroform—failure of respiration—and fail to recognize the danger to the heart that may arise in certain physiological conditions. They consider it unwise and unsafe in practice to pay no attention to the state of the circulation, and to observe respiration alone. Further, they consider it unwise to convey to the public, even through the profession, the notion that there is practically no danger in the administration of chloroform.* In the *Manchester Medical Chronicle*, January 7, 1891 (page 276), Dr. Lawrie, President of the Hyderabad Chloroform Commission, makes the following statement in answer to Alexander Wilson and others in their reviews of the Hyderabad Commission, published in the *Chronicle* of February 9, 1890. Wilson concludes his review as follows: "Increased knowledge has added nothing new to the direction for its (chloroform) administration." Lawrie states: "The Hyderabad Commission was appointed to confirm or disprove Syme's and Simpson's principles that we should be guided as to the effect of chloroform entirely by the respiration. The commission has not only proved that these principles are sound, but has also proved that the art of administering chloroform with safety consists in keeping the breathing absolutely regular throughout the inhalation." This proof is new, and has never been established before. After criticising the teachings of Wilson, he states that the commission has shown, 1, that the lowering of the blood-pressure, which chloroform and all anæsthetics cause when efficiently administered, is in

* British Medical Journal, Editorial, June, 1890.

itself a harmless event if the respiration alone be attended to and taken as a guide, and if the administration be stopped when the patient is fully anæsthetized; and 2, that the sudden falls of pressure, which the Glasgow Committee asserted are dangerous and attributed to chloroform, are due to stimulation of the vagus, and, by slowing the circulation, are a safeguard against overdoing.

The commission further proved that all irregularities in the fall of the blood-pressure and in the circulation under chloroform, including such an irregularity as dilatation of the heart, which occurs when chloroform is administered properly, are due to improper administration with irregular breathing and insufficient air (page 277). Again (page 278), every medical man ought to be able to give a dose of chloroform with as much precision, as certainly as a dose of morphine or of any other poison. The practical outcome of the disastrous teachings of the Glasgow Committee, backed up by Professors Wood and MacWilliam, is, that the relief of pain by chloroform is to be handed over to the specialists, who alone are to administer it, though their own declarations and statistics show that they cannot give it with safety. Exactly in proportion as this teaching gains ground, the profession suffers loss in credit and in pocket, and the advantages which chloroform confers are most seriously restricted and curtailed.

The extensive experiments of the Commission have left the chloroform question in the following condition:

It was not found possible to directly paralyze the heart (of dogs) by chloroform in some 600 administrations. Death from chloroform is due apparently from paralysis of the vaso-motor and respiratory centres—probably one or both of these may be affected. When death occurs, it is the result of an overdose of the drug.

The most conclusive statements and experiments are given in the paper of Dr. MacWilliam in answer to the strictures and conclusions published by Dr. Lawrie.

"In the *Medical Chronicle*,* January, 1891, Surgeon-Major

* Medical Chronicle, Manchester, 1891, xiii., 352–355.

Lawrie, in an article on the Hyderabad Chloroform Commission, makes some comments on certain results obtained by me in a recent investigation on the action of chloroform and ether published in the *British Medical Journal*, October 11, 18 and 25, 1890.

"In my paper I described the frequent occurrence of dilatation of the whole heart under the influence of anæsthetic doses of chloroform. Such dilatation was not due to changes in the pulmonary circuit, or to fall of arterial pressure."

Dr. Lawrie urges that the cardiac dilatation was due to obstruction of the circulation of the lungs, or to this along with a fall in the blood-pressure. He says: "The irregularities in the tracings of the Glasgow Committee, and Professor MacWilliam's recent bogie of dilatation of the heart, are due to obstruction of circulation in the lungs through interference with, or irregularity of, the respiration." And later: "Obstructed circulation in the lungs, and a rapidly falling blood-pressure, are more than enough to account for the dilatation of the whole heart, which occurred in his experiments, and which he wrongly attributed to the direct action of chloroform.

"Nor can this hypothesis of Surgeon-Major Lawrie's be briefly and conclusively disposed of. There is an abundance of decisive evidence available. First, as regards the alleged influence of obstruction of the circulation in the lungs, in causing dilatation of the heart. In my paper, in the *British Medical Journal*, I stated the fact that such an explanation was incompetent to explain the cardiac condition, since the whole organ was dilated in my experiments. Dilatation of the right side of the heart might conceivably (if there were no evidence to the contrary) be accounted for by the pressure of pulmonary obstruction, but dilatation of the left side (*e.g.* the left auricle) could clearly not be accounted for in the same way, since pulmonary obstruction necessarily diminishes in a large measure the flow of the blood into the left auricle, and this part becomes small and collapsed. This seemed so obvious to me that I did not discuss the matter at any great length."

I shall now state, briefly, some facts in regard to Surgeon-Major Lawrie's hypothesis of obstructed circulation in the lungs:

"1. There is no proof whatever of the occurrence of pulmonary obstruction from the administration in mammals of anæsthetic doses of chloroform, sufficiently diluted with air, as was the case in my experiments, the amount of chloroform vapor in the air never exceeding four per cent.

"2. On the other hand, there is decisive proof that pulmonary obstruction was not present in my experiments. Obstruction of the circulation would necessarily cause distension of the pulmonary artery as well as, and indeed earlier than, distension of the right heart. The pulmonary artery would become large and tense in consequence of the increased peripheral resistance to the outflow of blood from that vessel. Then the increased tension would react upon the right heart and cause distension there also. But in my experiments there was no distension of the pulmonary artery during the administration of chloroform. The vessel did not become distended ; it was soft and compressible, and the tension within it was low. It is quite certain, then, that pulmonary obstruction could not have been the cause of the dilatation, even on the right side of the heart.

"3. Even if pulmonary obstruction had been present—as was not the case—such obstruction could not have produced the condition which I described, or anything similar to it.

"I have on various occasions purposely brought about a condition of pulmonary obstruction by mechanical means with a view to studying the features of this condition. This I did by injecting into one of the great systemic veins some particular substance, *e.g.* lycopodium powder, which would cause embolism of the pulmonary vessels and so obstruct the circulation in the lungs. When such a substance is injected into the vein, it rapidly passes through the right heart into the pulmonary vessels, speedily causing more or less extensive and sudden obstruction of the pulmonary circulation, according to the amount and suddenness of the injection."

The effects resulting from the plugging of the minute pulmonary vessels induced in this way are very noteworthy, and illustrate clearly the consequence of obstruction of the circulation of the lungs. The pulmonary artery swells up and becomes largely distended, while at the same time the vessel feels

hard and tense to the touch; the pressure within the vessel is greatly elevated. The right ventricle, and the right auricle also, partake in the condition of distension, being unable to discharge their contents in the normal fashion in face of the greatly augmented resistance in front. The lungs become pale and anæmic. Meanwhile it is important to observe that the left auricle becomes smaller and collapsed-looking, in consequence of the obstacle offered to the passage of the blood through the lungs. Strong respiratory efforts, with convulsions of the asphyxial type (accompanied by spasmodic contraction of the systemic arteries) supervene in consequence of the stoppage of the respiratory purification of the blood; the medullary centres become violently stimulated by the venous character of the blood. Death speedily follows.

"It is unnecessary to enter closely into a comparison, or rather contrast, of the typical illustration of pulmonary obstruction here afforded, and the condition of cardiac dilatation which I have described as occurring under the influence of chloroform. It is obvious that obstruction of the circulation in the lungs produces changes strikingly different from those that result from the action of chloroform; and that the hypothesis of pulmonary obstruction may at once be dismissed as entirely insufficient and inapplicable, so far as explanation of the cardiac dilatation occurring under chloroform is concerned.

"Seeing that it is easy to dispose of the question of pulmonary obstruction in regard to the effects of chloroform upon the heart, I shall now advert briefly to the possibility of cardiac dilatation being dependent on a rapidly falling blood-pressure, as alleged by Dr. Lawrie.

"This is a matter which I carefully considered in my paper, and in regard to which I was able to state definitely that the cardiac dilatation is not due to a fall of blood-pressure. This is conclusively proved by the following facts: 1. Dilatation of the heart does not by any means always run parallel to the fall of pressure which ordinarily results from the administration of chloroform. Sometimes there is a very marked fall of pressure, with little or no dilatation of the heart, while at other times the heart begins to dilate before the pressure begins to fall.

2. Moreover, the heart in some instances begins to dilate during the temporary rise of pressure which at times precedes the fall. 3. Further, there may be distinct dilatation of the heart without any change of pressure at all. 4. Lastly, it can easily be shown that a simple fall of pressure, equal in amount to that which ordinarily occurs under chloroform, induced by means which do not directly affect the heart—*e.g.*, section of a vasomotor nerve, hæmorrhage, etc.—does not cause dilatation of the organ as chloroform does.

"It is clear, then, that the dilatation of the heart brought about by chloroform cannot be due to obstruction of the circulation in the lungs, or to a fall of systemic blood-pressure; it must result from a depressing influence exerted by the anæsthetic on the organ, 1, directly; or 2, through the vagus nerves.

"Finally, as this depressing influence, leading to dilatation, is readily manipulated after section of both vagi, it is obvious that chloroform must act upon the heart directly. I cannot help feeling that even a comparatively slight amount of actual observation of the features and results of a simple lowering of the blood-pressure and of real pulmonary obstruction would have prevented Surgeon-Major Lawrie from putting forward and adhering to such a hypothesis as I have here discussed—a hypothesis at once insufficient, absolutely untenable, and in conflict with large and somewhat elementary facts in the physiology of the circulation."

Respiration After Chloroform Asphyxia.

There is no doubt that in India deaths do occur (see case No. 43) from the administration of chloroform, yet we know from the facts stated in our work that the climate of that region, like our Southern States, is favorable to its use as an anæsthetic. Recently there has come to our notice, while in search for facts on the subject of prevention of deaths from chloroform, the following cases and opinions of practical surgeons, which we consider worthy of most serious attention.

Two cases of chloroform asphyxia were reported by Surgeon-Major Bartholomew and Civil Surgeon Ahmedabad. *a.* A patient aged 31, thin and emaciated, had suffered eight years from

vesical calculus. He was operated on and the stone, weighing 50 ozs., extracted, when it was observed that respiration had ceased. Ether hypodermically and the usual remedies were used without effect, and artificial respiration (Sylvester method) continued for *three hours* before the patient took a long breath (the heart action, though feeble, had not ceased). Six drachms of chloroform had been given.

A patient aged 18 had had 5 drachms of chloroform given prior to enucleation. After the operation the breathing was observed to have ceased, and the patient could not be roused. Artificial respiration was carried on for *one hour*, and on giving a galvanic shock the patient recovered consciousness. Drs. Pechey, Phipson, Banks, Maconachie, Meyer and Collee, all of the Army of India, cited instances in their experience of prolonged chloroform asphyxia, and ultimate recovery by artificial respiration and the galvanic shock. Dr. Meyer stated that there was a danger of inducing delirium of the heart by the prolonged use of electricity (this is the case when applied too near the heart), and thereby superadding a serious complication which might in itself prove fatal. Frequently patients did not breathe for some time after artificial respiration, because the lungs had had such a large quantity of air thrown in as to do away with the physiological reflex stimulus to the respiratory centre.

We do not in our work advise the use of hypodermics of morphine or atropine before the use of chloroform as an anæsthetic, and would call attention to this case, also, as the surgeon did not employ the galvanic shock, and did not keep up the artificial respiration long enough.

In a discussion which took place in the Paris Society of Surgery, upon a paper* treating of the use of hypodermics of morphine and atropine before the inhalation of chloroform, the author of the paper, M. Regnier, was led to try this method in his practice by the recommendation of M. Dastre, who reported favorable results from its use in animals, and of M. Aubert, a surgeon, who stated that narcosis and awaking were facilitated

* L'Union Médicale, August 5, 1890.

by the injection of $\frac{1}{4}$ gr. morphine muriate and $\frac{1}{85}$ gr. atropine sulphate fifteen or twenty minutes before the operation, and that inconvenient results were observed but rarely. M. Regnier used this method with a number of patients, until, unfortunately, a fatal accident occurred.

A feeble girl, aged 16, was affected with tubercular disease of the bones of the foot, and, as the lungs presented but a few râles in the apex of one side, he decided to chisel out the cuboid bone. Half an hour before the operation he gave a hypodermic injection of $\frac{1}{12}$ gr. of morphine and $\frac{1}{250}$ gr. of atropine. Anæsthesia was easily induced, and not more than from five to seven fluid drachms of chloroform were required for the whole operation, which lasted only a few minutes. About ten minutes after the chloroform had been removed, and while the dressings were being applied, she opened her eyes without speaking, and was then carried to her ward. Three minutes later news was brought that she had ceased breathing. Upon reaching her bed he found the respirations very infrequent. They ceased suddenly as the pulse disappeared, although feeble heart-beats were still heard. The pupil then quickly dilated. Protracted artificial respiration seemed, at the end of half an hour, to excite spontaneous respiration, but this soon failed, although supplemented by ether injection and other methods. Post-mortem examination showed anæmia of the cerebral hemispheres and medulla oblongata.

Death in this case came on very slowly from chloroform intoxication. It was quite remarkable that life could be prolonged for more than twenty minutes by artificial respiration. It was claimed that the chloroform must have been eliminated slowly, and that the elimination was rendered more slow than it would otherwise have been by the influence of the morphine and atropine.

Two members of the Society reported that they had observed in experiments on dogs, that morphine and atropine given before chloroform, produced no reflex phenomena at the beginning, but rendered much more grave such complications as appeared at the end. In some cases there was quite protracted and severe dyspnœa. In dogs thus treated very little chloro-

form was needed ; in men more was required. It appeared to be conceded that the method was useful in the laboratory but not in the clinic, as the chances of intoxication were increased.

Another member who had tried the method, stated, that in male patients nothing worthy of note was usually observed, while in female patients the awaking was much more slow than with chloroform alone. He thought women were more sensitive than men to the influence of atropine. Out of five cases he had lost one patient. The operation was for nephrectomy, and lasted an hour, fifteen fluid drachms of chloroform being used. After a short awakening the respiration began to fail, cyanosis appeared, and in spite of all measures, death occurred in an hour and ten minutes.

Conclusions.

1. During the protracted use of chloroform as an anæsthetic, the blood is changed in character, lowered in pressure, with weakening of the action of the heart and changes in its structure.

2. Dilatation of the heart occurs under the use of chloroform at all stages on both sides of the heart, while the heart muscle is weakened.

3. Cardiac failure occurred before respiration in thirteen instances out of forty-three cases of death from chloroform.

4. The depressing influence of chloroform on the heart mechanism is not exerted through the vagus nerves, and section of both vagi does not obviate the weakening and dilating influence of chloroform on the heart.

5. Too many trifling operations are performed under chloroform ; its use should be reserved for those cases in which ether, nitrous oxide, or cocaine will not produce the anæsthesia desired.

6. Ether deaths, as a rule, occur in patients of a certain class, usually from obstructed respiration, and occasionally the heart will stop first, as in two of the four cases in our tables.

7. Watch both pulse and respiration, both in chloroform and ether ; when the breathing becomes very rapid, danger is near.

These changes are apt to follow the first act of respiration. Chloroform vapor should not be employed over four per cent.

NOTES REFERRED TO IN THE TABLE.

Note 1.

Paralysis of pneumogastric nerve, the direct effect of the chloroform, superinduced by effort at vomiting.

Note 2.

Respiration failed gradually, at one time stopping, and commenced again after artificial respiration.

Note 3.

Anæsthesia not complete when operation commenced, and heart and respiration ceased.

Note 4.

Four Deaths from the Inhalation of Chloroform in Reading and Vicinity During the Past Three Years.*

On April 8, 1890, at a meeting of the Berks County Medical Society, a paper was read, entitled "Chloroform Anæsthesia," by Dr. John T. Carpenter, of Pottsville, Pa., which was published in the University Medical Magazine, June, 1890. The drift of this paper and the discussion which followed was that chloroform, if skilfully administered, was a safe anæsthetic, and was preferable to ether on account of its safety, speediness of action, and general absence of any unpleasant sequelæ. This discussion disclosed almost a unanimous opinion favorable to the use of chloroform as an anæsthetic. One distinguished medical officer of the United States Navy and two representative physicians of Philadelphia were present, and they all displayed a strong preference for the use of chloroform. Only one physician besides myself, Dr. W. Murray Weidman, a gentleman of large sur-

* By John W. Keiser, M.D., Reading, Pa., University Medical Magazine, August 6, 1895.

TABULAR STATEMENT SHOWING THE "DEATHS FROM CHLOROFORM AND ETHER SINCE THE HYDERABAD COMMISSION."

Date.	No.	Name, Age and Sex.	History.	Nature of Operation.	Anæsthetic, Amount Used	Apparatus Employed	Posture.	How Long Under Influence	Heart or Respiration Stopped First	Means to Resuscitate	How Long Continued	Post-Mortem.	Cause of Death	Reference.
1887–1896	1	——, 61, M		Reduction of dislocation of femur.	Chloroform.				Heart			Heart thin walls.	Syncope	Lancet, Lond., 1890, ii., 935.
	2	J. F., 36, M		Suture of patella.	Chloroform. 1½ oz	Inhaler			Heart	Usual.		Fatty heart	Syncope	Lancet, Lond., 1890, ii., 935
	3	——, 72, F		Removal of eye	Chloroform				Not stated			Fatty heart, 14 ounces	Syncope	St Bartholomew Hosp. Rep., London, 1890, xxvi. (in Statistical Tables), p. 97.
	4	——, 1½, M		Setting of fracture	Chloroform							Heart greatly dilated and hypertrophied. Weight more than that of a 3-year child		St Bartholomew Hosp. Rep., London, 1890, xxvi. (in Statistical Tables), p. 97.
July 2, 1889	5	——, 5, M		Curetting tuberculous sinuses	Chloroform, 1 oz Had taken it three times previous	Towel		1½ minutes	Respiration	Usual, resp'n returned and ceased again.				Med Rec, N. Y., 1890, xxxvii, 289.
June 19, 1889	6	——, 2, F	Spina bifida, good health and robust	To evacuate.	Chloroform	Towel.		10 minutes, not profoundly.	Respiration	Usual		No cause of death found Heart normal		Ibid
Sept. 29, 1889	7	P B, 68, M	Stricture of urethra, etc.	Suprapubic cystotomy.	Chloroform			5 minutes	"Cyanosis, no pulse"	Usual		None		N Amer Pract, Chicago, 1891, ii, 463
Nov. 9, 1890	8	M C Jones, 11, F		Removal of mole from face	Chloroform, very little.	Esmarch inhaler	Placed on operat'g table		Together.	Yes	1½ hours	None		Jour Am Med Assn, Chic., 1891, xvi., 232.
Aug. 5, 1890	9	——, 16, F	Tubercular disease of foot	Upon cuboid bone	Chloroform, 5–7 drms			Few minutes	Respiration	Seemed to excite at end of half hour, but then failed.	1½ hours	Anæmia of brain		L'Union Médicale, Aug 5, 1890
Jan 10, 1891.	10	——, 44, F	Cancer	For removal	Ether			Less than min Operation not commenced	Heart	Yes.		None	Heart failure	Brit. M J, Jan. 10, '91.
	11	Albert Bate, 21, M	Chronic abscess		Ether, had used chloroform and nitrous oxide before at times							Fatty degeneration generally Heart 11 ounces.	Syncope	Brit M J, Oct 11, '90
	12	——, 41, F		Tracheolorrhaphy.	Chloroform	Inhaler			Respiration			None.		Brit M J, Dec 21, '90.
Feb., 1891.	13	E. Vials, 21, F	Lupus of nose. Had had 5 or 6 operations under chloroform	To remove	Chloroform	Skinner's inhaler		For 8 minutes	Respiration	Usual—Sylvester's.	¼ hour	No evidence		
	14	——, 30, F.	Good	Removal of tumor—face	Chloroform, 2–3 oz				Respiration	Usual		No lesion found.		Lancet, London, 1890, i, 1140
	15	R. Costa, soldier, 25	Good	Incision in inguinal region.	Chloroform, about 25 gms.	Esmarch inhaler		Few inhalat'ns	Heart	Usual	2 hours	Congestion of brain, old pleurisy, fibrous pericarditis Fatty heart, renal congestion	Paralysis of heart	Gior Med d. r. esercito, etc, 1891, xxxix., 31–54
	16	Mrs. R, 37, F	None	Tracheolorrhaphy and perineorrhaphy.	Chloroform, had used twice before.	Esmarch inhaler		2 minutes	Heart			No results.		Daniels' Texas M J, Austin, 1889–90, v., 218–251
	17	J., 42, F	Ovarian tumor, emaciated		Chloroform	Napkins folded in cone	Dorsal decubitus.	Few inhalat'ns Died 1½ min	Heart	Usual		No results of value	Syncope in first stage.	Ibid
Feb. 2, 1890	18	E. L P, 41, F	Cancer of stomach.	Resection of pylorus	Ether, 110 c cm			1½ hours				Nothing notable		Hygiea, Stockholm, 1890, 370–374
June 5, 1890	19	——, 5 months	Intestinal obstruction	To explore.	Chloroform, 1½ oz	Towel and drop bottle			Heart—almost together.	Usual	35 minutes	Lungs congested; heart healthy	Par of respir'y & car. centres.	Brit. M J., Lond., 1890, i, 1425.
Dec 7, '90 (?).	20	——, 17, M			Chloroform, 6 oz	Wire and lint mask		20–22 minutes	Heart	Sylvester's and usual	½ hour	None	Reflex paralysis of heart	Lancet, Lond, 1891, i., 330.
Dec 19, '90 (?).	21	J. C, 46, M	Contraction of right elbow-joint, 11 months' duration, due to burn		Chloroform, oz iiss.	Esmarch inhaler and drop bottle		7 minutes.	Heart resp'n continued 30 seconds after	Usual		General congestion, heart normal, liver slight, fatty brain œdematous		Brit M J, Lond., 1891, i, 461
April 29, 1890	22	Mrs. —— F	Sensitive teeth	Extraction of tooth	Chloroform, had used it a number of times before, once 1 oz used.		On back.	60 seconds	Together	Usual		None.	**See note 1**	N Am Jour. Homœop., N Y., 1891, 3, s. vi., 164–167
Mar 27, 1890	23	Thomas O, 41, M	Ulcers of leg, tetanus, lower jaw fixed; convulsive movement of constrictors of pharynx		Chloroform			Only partial chloroform	Heart failure, cessation of respiration.	Artificial, usual, etc, puncture of heart				N. Amer Pract, Chicago, 1891, ii., 163
June 18, 1890	24	John Q, 52, M	Pulm'ry phthisis, chronic nephritis, tubercular rib, abscess in pectoral muscles.		Chloroform, had used before Ether was contraindicated	Inhaler		Few minutes	Heart	Usual	¾ hour	Heart, soft walls, left vent empty, hypertrophied pleura adhesions, calcareous nodules, both lungs, Peyer's patches and solitary glands enlarged tuberculosis second right rib, sinus at apex of right lung, kidney contracted		N Amer Pract, Chicago, 1891, ii, 164
Nov. 1, 1887	25	J M	Tumor of face of 4 months. Cirrhosis of liver, murmur over mitral area	To explore	Chloroform, had only taken ½ doz respirations	Towel	Semi-sitting		Heart	Usual		Tumor was "spindle cell sarcoma" heart 22 ozs, cavities much dilated, mitral cusps thickened arch aorta atheromatous, liver 82 ozs., congested and fatty; kidneys congested and fatty		Brit Guiana M Ann, Demerara, 1890, 103–108
Nov 16, 1889	26	——, 41, M	Epithelioma of tongue, ulceration, etc Had been a hard drinker	The removal of epithelioma	Chloroform, 2½ oz				**See note 2**	Usual	¾ hour	No information to help in the case.	Failure of respiration	N Orl M and S J, 1889–90 n s, xvii, 726
	27	——, 50, M	Feeble man; curvature of spine, 15 years' duration bronchitis, chronic.	Abscess of left thigh	Chloroform had used before.			Just beyond the struggling stage	Together.	Artificial respiration	½ hour	Heart flabby containing fluid blood, valves healthy liver fatty, kidney fatty, brain normal; caries and ankylosis, and 4 lumbar vert.		Brit M J, Lond, ii., 1890
	28	——, 65	Tumor in abdomen		Chloroform, anæsthesia incomplete			**See note 3**	Respiration			Malignant disease of stomach		Ibid, i, 29
Mar 26, 1890	29	——, 56, M	Fracture of thigh		Chloroform			Death took place before oper begun						Med Rec, N Y, April 19, 1890
Mar 29, 1890	30	S G, 28, M			Ether								Fatty heart	Med Rec, 1891.
April, 1890	31	Evans, 39, M	Lupus	For lupus.	Chloroform					Usual		No evidence	Asphyxia	
Oct 25, 1890	32	Gregory, 49, M	Facial neuralgia	To relieve.	Chloroform, 20 drops	Handkerchief								
July 12, 1890	33	Bird, 9, M	Rupture of eye		Chloroform					Yes				Brit M J, July 12, '90
	34	——, M.	Pneumothorax, had used chloroform before.	To explore	Chloroform				Together	Yes		Heart healthy	Heart failure	Ibid, Oct, 1890.
Nov. 10, 1890	35	Jno Goulden, 7, M	Affection of knee	Amputation										Lancet, Lond, 1890, ii., 1113
1890	36	I L S, 25, F	Cystic sarcoma of ovary	Abdominal section	Chloroform, f℥iss	Tait's apparatus		30 minutes,	Heart failure	Artificial respiration, hypodermics, electricity, etc		No organic disease of the heart recognized before death No post mortem.	Heart failure	Private contribution from Dr Jos Leidy, Jr, University Hospital, Philadelphia
Jan 26, 1890	37	I. R, 21, M	Acute lobar pneumonia had influenza, etc.	For radical cure of oblique inguinal hernia.	Chloroform (Squibb's), less than 8 c cm.	Towel over face		5 minutes.	Respiration.	Everything, artificial respiration	Some time	None noted	No assignable cause; one of those cases due to some peculiar idiosyncrasy	Reports of Surg-Gen Marine Hosp, Washington, 1889–90, xviii., 159
Feb 15, 1890	38	L Smith, 22			Chloroform									New South Wales, Albury Hospital
Apr 14, 1890	39	G. Galvin, 24			Chloroform									Prince Alfred, New South Wales
May 17, 1890	40	C. Segol, 27			Chloroform									Prince Alfred, New South Wales.
May 19, 1890	41	C. Golan, 4			Chloroform									Prince Alfred, New South Wales
Jan. 3, 1891	42	R. Metrani, 30, F	Injury to face	Plastic operation	Chloroform, not excessive	Inhaler			Heart, resp'n ceased a few seconds after.	Usual	1 hour	None	Heart failure	Indian Med Gaz, Calcutta, 1891, iii, 76
Mar 13, 1891	43	A M W, child, F	Leucoma of right eye	Iridectomy	Chloroform, took it well.				Respiration	Usual	10–15 mins	Heart normal, empty; pleurisy both lungs, other organs healthy.		Brit M J, Lond, 1891, i, 800
Since 1890	44													
	45													
	46													
	47	**See note 4.**												
1890	48		Fistula in ano		Ether			Died during operation.					Fatty heart	Med Rec
1890	49	F.	Abscess in leg		Ether			Died before operation.						Med Rec, Mar 29, '90
Jan. 10, 1890	50				Chloroform									Lancet Lon, Jan 10, '91
Jan, 1891	51	F	Cancer	For removal	Ether			Less than 1 m	Heart	Usual			Heart failure.	Brit M J, Jan. 18, '91.
Oct 29, 1891	52				Ether				Respiration					Med Rec, Nov. 16, '91
Feb, 1891	53	J. P., M	**See note 5**		Ether 15			Less than 1 m	Respiration.	Usual	3 hours			J A M Assn, Feb 1, '91
	54	M, 15		Extraction of teeth	Chloroform	Towel	Sitting							Lancet Lon, Mar 12, '93
June 27, 1893	55	J K, 3½, M			Chloroform	Towel		Died before operation.					Paralysis of heart	N Y, Herald, Aug 20, 1893
July, 1893	56	M. B, M	Dislocated shoulder.		Chloroform	Handkerchief		Few minutes		Artificial respiration		Heart dilated, walls softened liver slightly hardened, kidney enlarged, evidence of alcoholic habit	Convulsion	Med News, Philada., Sept, 1893
Feb 9, 1894	57	——, 41, M	Intestinal obstruction	Laparotomy.	Chloroform, 23	Lint		35 minutes	Respiration.	Usual		Heart muscle in a state of fibrous degeneration	Cardiac syncope	Lancet, Lon, Mar. 10, 1894
Mar 24 **See note 6**	58	Col S, M	Stone in bladder.	To be removed	Ether			Few minutes		Artificial respiration and every other means		Lungs showed a large amount of bronchitis, liver large and cirrhotic, weight 6 lbs 14 ozs kidneys enlarged death due to the man's condition.	Œdema	
Nov. 11, 1891	59	H M, 6, F			Ether, ½ to ¾ ℥			10 minutes	Together	Artificial resp, hypodermics, electricity, oxyg'n forced in lungs, etc	25 minutes.	Cleansing ulcer		Private Hospital Record.
1896	60	H. A., 16, M	Necrosis of jaw Had been operated before.	To operate abscess near eye	Ether	Gauze		Few minutes.	Respiration	Every means	¼ hour	Lungs filled with miliary tubercle, heart diseased.	Paralysis of respiration	Private Hospital Record.

Deaths from ether, 12; from chloroform, 70. Our Table not being as complete as we desired, we have made an abstract of the results obtained by Dr Gould page 314, also, the Table of Dr. Hewitt, page 332 It will be noted that we have only duplicated one (*i.e.*, Dr. Hewitt's case, No 54), which supplements and completes our Table.

gical experience, declared himself favorable to the use of ether.

He in substance said that he never had any experience with chloroform; that he always used ether, and that the exigencies of railway surgery were such that he frequently operated while an ordinary workman administered it, and that he never had any disastrous results from its employment. In this discussion I opposed the use of chloroform with all the ability that I could command, and made the prophecy that if the opinions I had just heard would be put into actual practice they surely would result in an occasional death from the use of chloroform, which could have been avoided by the use of a safer anæsthetic; and it was not necessary for me to wait many years before the truth of this prophecy was realized. I give the particulars of this meeting as it reveals the attitude of the local profession towards the use of chloroform.

In this community a large number of physicians are very favorably disposed to the use of chloroform; I am, nevertheless, absolutely certain that it is not as frequently used as ether; and if these two anæsthetics were of equal safety the deaths resulting from the use of ether would exceed those from chloroform. In a paper published by me August, 1890, in the Magazine, which was designed as a reply to Mr. Carpenter's paper, I stated, after investigation, that I had learned of two deaths from chloroform in this locality, and was unable to discover any from ether. Since then two more deaths from chloroform have happened in this vicinity, making a total of four.

With a view of impressing upon the profession the unavoidable dangers attending the use of this dangerous anæsthetic, I will briefly relate the circumstances of these last two deaths. About three years ago a competent physician of this city, now deceased, went to a neighboring village to operate on a multiple stricture of the urethra in a middle-aged gentleman. After the chloroform was inhaled a few moments the patient, without a moment's warning, suddenly died. The physician who gave the anæsthetic admitted to me in private conversation that the only cause of death in this case was chloroform, and expressed regret that he had not used a safer anæsthetic.

About one month ago a girl of 16 applied to the Reading dispensary for the removal of a small but disfiguring growth upon one of her eyelids. The two competent physicians endeavored to persuade her to submit to the operation without an anæsthetic, but she insisted upon having it. According to a newspaper report, made by the attending physicians, about fifteen drops of chloroform were placed on a towel, and after taking several inhalations she sprang from the table. She was again persuaded to get on the table, and the instant the inhalations were recommenced she died. The coroner's jury rendered the following verdict: "Death was caused by heart-failure while being put under the use of chloroform. . . . . We agree that the chloroform was administered in the usual professional manner." The physicians in this case contended that the girl died from fright, and not from the anæsthetic; but I think that the verdict was a just one, and that fright was insufficient to account for death. If it was a factor in the death of this unfortunate girl it was only possible in conjunction with the paralyzing influence of chloroform.

I believe that if all deaths from chloroform were published in the medical journals the number would be enormous, and the publicity would compel the abandonment of chloroform as an anæsthetic, save in a few cases in which it would be specially indicated.

Note 5.

"In the case given there is little doubt that a valuable life might have been spared. A youth, aged 15, required eleven teeth to be taken out to qualify him for admission into the Royal Navy. An appointment was made by a dentist with the youth's own medical man to give chloroform. We do not wish to pillory this gentleman, with whom we deeply sympathize for the terrible disaster with which he is associated; we are aware that very many practitioners adopt the plan he resorted to and recognize it as a routine procedure in dental operations. We must, however, most emphatically denounce it as a dangerous and undesirable one. Chloroform was administered with a towel—a method which easily induces an overdose of the anæs-

thetic—and the pulse was kept under observation. We read nothing of the respiration or the pupil, though doubtless they, too, were kept under observation. The dentist removed one tooth, and finding the second somewhat difficult some delay arose, during which the boy partly came round. The chloroform was readministered and the remaining teeth were removed. Then the patient died. In a report which is before us we read that the medical man in his evidence said: 'Turning round again, he noticed a change in the patient's condition.' It is significant how often 'going wrong' occurs when the back is turned. The necropsy—performed by an independent medical man—revealed, we are informed, the startling fact that on examination of this boy, who is described as being in 'perfect health' and as having been passed for the Royal Navy at headquarters except as regarded his teeth, that his lungs were in such a condition that 'the boy could not have lived above two years.' Surely no lesion so serious could have escaped the examination at headquarters, and that of the medical man who expressly states he scrutinized the lad before giving him the chloroform. The posture of the patient is not mentioned; probably the boy was in the dentist's chair—a position unsuited for the administration of chloroform."—London Lancet, March 12, 1893.

Note 6.

Deaths from Ether.

Our friends think we have in our previous editions not given so much prominence to the deaths from ether as to those from chloroform, still we can state truthfully that our work will be found to contain the whole number of deaths from all anæsthetics as far as we have been able to collect them, sparing no time nor money in the effort to do so, and these deaths were reported in full not only before the meeting of the British Medical Association in 1893–4, but also published to the medical world, and in this edition we publish some additional deaths.

Official Statement from the Paris Edition of the New York Herald, March 27, 1893, by His Physicians, as to the Death of Colonel E. F. Shepard from Ether.

At the request of Mr. Chauncey M. Depew and the members of the Shepard family, Drs. McBurney and McLane have published the following statement:

"We met at Colonel Shepard's house for the purpose of making an exploration, under ether, on the bladder, and proposed, if practicable, to remove the stone which it contained. The presence of the stone was determined by two careful examinations on February 24th and March 9th. These examinations, which were made without the use of an anæsthetic, gave the patient some pain. Between Feburary 24th and March 24th several examinations of the urine were made, but no evidence of any organic disease of the kidneys was found. The heart and lungs were healthy, and, after a careful examination, no disease, such as might interfere with the proper performance of the operation, was discovered. The operation was postponed at Colonel Shepard's request until March 24th. We especially instructed him to eat very lightly on the day of the operation and to take no food afterwards.

Before the Operation.

"We found Colonel Shepard in his study, apparently in good spirits, but he felt a little nervous about the operation. He removed his clothes, wrapped himself in a dressing-gown, looked about the room and at the seemingly elaborate preparations and expressed surprise at their detail. He was told that they related chiefly to surgical cleanliness and were no greater than would be made at a good hospital.

"At a quarter to one o'clock the administration of ether was commenced, it having first been explained to him that he was to take full inspirations and not to offer any resistance, in order to come more rapidly under the influence of the anæsthetic. For a few minutes he inhaled the ether uncommonly well, breathing full and freely. His color then changed somewhat,

he was apparently nauseated and in another moment vomited. After that his color was better, but his respiration was not satisfactory nor was his pulse. The further administration of the anæsthetic was therefore discontinued, but as yet not enough ether had been given to continue the proposed operation.

"All our efforts were now directed to securing proper respiratory action. As usual in cases where the respiration is not perfectly satisfactory, the breathing continuing very labored, an examination was made of the larnyx to discover whether possibly a particle of food had lodged in it, but this was proved not to be the case.

"EXTREME MEASURES RESORTED TO.—The patient's condition was now so alarming as to call for extreme measures, and, in the hope that the symptoms were due to the presence in the windpipe of vomit material, accidentally inhaled, the operation of tracheotomy was performed. No foreign material was found. We even passed a rubber tube down the windpipe into the bronchial tubes, making use of a powerful aspirating syringe, without discovering the presence of anything but bloody mucus.

"In the meantime several careful examinations were made of the lungs, and sounds heard indicated œdema of these organs. Oxygen had been previously sent for, and under its influence the patient slightly revived. Artificial respiration and every other means that might possibly give relief were resorted to. From this time onwards the patient's breathing was even more embarrassed, but still artificial respiration was continuously kept up, although the pulse became steadily more feeble. Colonel Shepard sank rapidly into unconsciousness in spite of all our efforts, and died at ten minutes past four.

"THE CAUSE OF DEATH.—Our opinion is that Colonel Shepard died from sudden œdema (congestion of the lungs) following upon the administration of ether, but primarily due to some cause unknown to us.

"JAMES W. MCLANE, M.D.,
(Signed) "CHARLES MCBURNEY, M.D."

ED. NOTE.—The unfortunate part of this case is that no post-mortem verified the cause of death.

The Relative Mortality of Ether and Chloroform as Anæsthetics.*

"In preparing statistics upon the subject of ether and chloroform as anæsthetics we have endeavored to adhere closely to certain principles of criticism which we reluctantly adopted as absolutely necessary in order to reduce the evidence before us to coherence. Data of varying degrees of merit, and obtained under such different conditions that it is the greatest carelessness to range them together as facts of equal weight, are nevertheless commonly found side by side. From such statistics we could not draw any definite conclusions. Nay, the conditions are ignored which we proposed to ourselves as the ultimate test of the value of any series of data. Are there, we asked ourselves, any observations recorded that show that ether and chloroform have been fairly tried together upon that common ground on which both may enter as anæsthetics and display their peculiar powers upon cases regularly selected with care and judgment? Pursuing this subject, we have been on our guard against any bias in ourselves and have carefully searched for it in the writings of others.

"The number of papers to be examined is astonishingly great. Most of them, we are sorry to say, are liable to the suspicion of partiality. Among those of doubtful authority, from our own point of view, which, it must be remembered, is purely critical, are the following: The experimental; those recounting individual experiences with ether alone or with chloroform alone; those that assume that the use of chloroform ought to be entirely abandoned; the controversial and polemic, of which unfortunately there are some. Secondly, we have noted as instances of that frame of mind which is unsuitable for fair judgment such statements as Surgeon-Major Lawrie's, that 'the most important result of the labors of the Hyderabad Commission has undoubtedly been to establish the proof that chloroform has never, under any circumstances whatever, a direct action upon the human heart;' or M. Julliard's confes-

* Editorial from The Medical News, Philadelphia, October 1, 1892, by Dr. George M. Gould.

sion that for ether he has long been '*un partisan convaincu;*' or again, his saying, too loosely we feel, that 'Prof. Tripier has administered ether without accident 6500 times, while on the other hand he had a case of death *sur un nombre infiniment moindre de chloroformisation.*'

"'It is enough to observe here that by following any party or school we cannot arrive at the truth. In our own judgment, it is assuredly unfortunate that men will use one anæsthetic exclusively, for some cases are fit for chloroform, others for ether, others again for nitrous oxide gas, still others, perhaps, for the A. C. E. mixture.

"Naturally, we have not found many statistics that are free from the faults that we have either pointed out or hinted at. Indeed, we know but one that is accurate, and has besides the merits we required. Such statistics, we felt bound, must show observation of scientific accuracy, taken during a considerable time, under uniform conditions, by men of approved ability and knowledge entirely interested in a fair trial of ether and chloroform, using neither one nor the other exclusively, but both alike and as nearly as possible an equal number of times; with registrations made at the time of the operation, of the number of cases, with the deaths and accompanying circumstances. By means of these statistics, and these alone, may we hope to arrive at a final judgment on the controverted claims of ether and chloroform. We append a table of these desirable data. It is compiled immediately from the St. Bartholomew's Hospital Reports. It includes all the observations made.

"It must be admitted that these results are by no means favorable to chloroform, yet we do not go so far as to say, with M. Julliard, that we must show these statistics to be inexact, or renounce chloroform. We see that the use of chloroform has increased with moderate fluctuations, reaching a maximum in 1890, and a preponderance over ether in that year of 727 cases, with one death for each anæsthetic. It is evident, then, that the surgeons had sufficient confidence in chloroform to continue its use—a fact in its favor. Whether this confidence is deserved we may judge by an examination of the circumstances attending the deaths. In the table we have noted the

cases of syncope; these may be left to speak for themselves. Of the remaining deaths, we may ascribe two to asphyxia. The others, we think, were highly probable with any anæs-

Number of Cases.				Deaths.			Remarks on the Cases Pertaining to Chloroform.
Year.	Chloroform.	Ether.	Ether Preceded by Nitrous Oxide.	Chloroform.	Ether.	Ether Preceded by Nitrous Oxide.	
1875	617	120	764	None	None	None	
1876	670	28	1004	"	"	"	
1877	699	23	1123	"	"	"	
1878	794	15	1009	1	1	"	Syncope after operation.
1879	975	23	984	1	None	"	Syncope after operation.
1880	1055	43	1304	None	1	"	
1881	1072	85	1209	1	None	"	Syncope before operation.
1882	1349	337	1076	2	"	1	
1883	1421	566	1156	2	"	None	
1884	1244	1016	704	None	"	"	
1885	1331	1118	386	"	"	"	
1886	1425	1109	567	1	"	"	Syncope before operation.
1887	1702	1197	662	1	"	"	Syncope after operation.
1888	1711	1003	349	1	"	"	
1889	1601	810	509	2	"	"	Syncope.
1890	1860	998	135	1	1	"	Syncope.
Total...	19,526	8491	12,941	13	3	1	
Proportion of deaths, 1875 to 1890.....	1 : 1502	1 : 2830	1 : 12,941				

thetic. Thus we have nine deaths out of thirteen, which sufficiently enforce the peculiar dangers of chloroform. With these facts before us we cannot feel any great degree of confidence in that anæsthetic. If, on the other hand, we look at the circumstances attending the three deaths under ether, we

shall see that they were almost inevitable. The report of the first is as follows:

"1. A man, aged forty-seven, died when under the influence of ether. He was suffering from intestinal obstruction, for which lumbar colotomy was undertaken. In the morning he had had a severe attack of dyspnœa. He was in a state of profound collapse at the time of the operation: his belly was tumid, his respiration shallow, and his pulse feeble. He vomited frequently, and after inhaling ether for ten minutes became livid and never again rallied.

"2. A man, aged sixty-one, suffering from strangulated inguinal hernia, died under the influence of ether. He had been delirious the previous night; his pulse was irregular and feeble, and he had constant vomiting. During the operation the pulse became imperceptible, and finally respiration ceased. At the necropsy the heart-substance was found slightly fatty; the cavities were nearly empty, containing no clots. The lungs were emphysematous; all the posterior parts were engorged with blood.

"3. A man, aged fifty-six, died under the influence of ether. He was a drunkard and had sustained a fracture of the tibia and fibula. After suffering from delirium tremens for ten days, ether was administered in order to reset the broken bones. This was satisfactorily done, and three minutes after the cessation of the administration of ether the heart suddenly ceased beating, then respiration stopped, and the patient died. A post-mortem examination showed the lungs much engorged, a flabby heart, and a fatty liver.

"We have given great prominence to these statistics on account of the merit they possess and the excellent model they furnish. We cannot be too grateful for them.

"Next to the statistics of St. Bartholomew, we selected others from the *Proceedings of the German Chirurgical Society*, Berlin, April, 1891. They are inferior in many particulars, and they furnish very few administrations of ether. The data were supplied by 66 colleagues, chiefly German, besides 3 Austrian, 3 Russian, 2 Swedish, 1 each from Holland and Belgium.

Bardeleben, from the Charité, 1878–90, sends statistics of over 12,000 administrations of chloroform with 7 deaths. In addition were reported:

	Cases.	Deaths.	Asphyxia.
Chloroform, ...	22,656	6	71
Ether alone, ...	470	0	0
Ether and chloroform, . .	1,055	0	5
		6	76

"There was thus one death in 3776 administrations of chloroform. The duration of the narcosis in 2732 cases was one hour; in 278 a longer time, sometimes from 150 to 155 minutes. In the Charité, in the last six years, 1 c.cm. of chloroform was used per minute during the narcosis. The greatest amounts used during an operation ranged from 150 c.cm. to 180 grams."

We have not space for all the tables of Dr. Gould, but we give his conclusions in regard to the relative mortality from ether and chloroform as follows:

"From 1875 to 1890, inclusive, in the St. Bartholomew Hospital, anæsthesia was produced 19,526 times by chloroform, 8491 times by ether, and 12,941 times by ether preceded by nitrous oxide. The number of deaths were respectively 13, 3, 1, giving the mortality of chloroform as 1 in 1502, ether as 1 in 2830, and ether preceded by nitrous oxide as 1 in 12,941.

"The most recent and probably the best is the table prepared by Dr. Gould, based upon that published by Julliard, who in turn used that of Compte as a foundation. In this table there are included 638,461 administrations of chloroform, with a total of 170 deaths; 300,157 administrations of ether, with a total of 18 deaths, giving a mortality of chloroform anæsthesia as 1 in 3749 and ether anæsthesia as 1 in 16,675."

"If we add Dr. Rabatz's experience with ether, 150,000 administrations without a death, we have the weightiest evidence yet adduced by a single expert of the superior safety of anæsthesia with ether."

Hospital Records.

We notice with regret that some of our hospitals are not careful enough in the record of their cases of anæsthesia.

The following are two forms of record, one more brief than the other.

First, the examination of the urine, placed on Card No. 1.

No. 1.

Date..

Name..............................Ward...................................

Urine.

Quantity..........................Color...................................

Reaction..........................Sp. Gr.................................

Albumen..................Sugar..................Urea.................

Remarks...

To be sent up with the patient before using the anæsthetic, and Card No. 2,

Name.................. Ward..............

Date.	Qt. 24 hrs.	Color.	Sp. Gr.	React.	Alb.	Sug.	Urea.	Remarks.

Is hung to his bedstead for daily record.

Urinalysis.

No. Name. Ward. Bed. Physician in charge.

Quantity in 24 hours. Color. Sediment. Sp. Gr. Reaction. $H.N.O_3$.

Boiling—methods of Tanret, Fehling, Trommer, Heller; microscope by the pathologist, with remarks.

Record.

No. Age. Date. Ward. Bed.

Character and kind of operation to be done.

Examination of the heart, lungs, urine, temperature before operating.

Pulse before and after operation, during and after anæsthetic is used.

Quantity employed, oz., drachms, drops.

Complications and treatment.

Recovery.

Death—how soon after.

Report of Autopsy.

No. Name. Date of death. Nationality. Height. Weight. General appearances of rigor mortis. Head. Thorax. Left pleura. Left lung. Right pleura. Right lung. Pericardium. Heart. Abdomen. Liver. Spleen. Left kidney. Right kidney. Intestines. Stomach. Pancreas. Bladder.

Remarks.

Pathological diagnosis.

Clinical diagnosis.

Date and name of pathologist.

An Abstract of the Deadly After-Effects of Chloroform.*

By Dr. C. Thiem and Dr. P. Fischer.

The knowledge that death can happen during chloroforming by paralysis of heart and respiratory organs (aux 100,000 Narkosen rechnet man 100–150 Todesfälle) is general, but the knowledge about the deadly after-effects is of more recent date, and less generally known.

There is no doubt, according to our research, that the elimination of chloroform or of its decomposing products (Zerset-

* Uber tötliche Nachwirkung des Chloroforms (Deutsche Medizinal-Zeitung, Berlin, 1889, x., 1111–1114). Translation by Dr. J. M. Lamb, Washington, D. C.

zungsprodukte) does not happen as quickly as was supposed (two days), but that, for instance, elimination through the urine has happened twelve days after chloroforming.

As long as this product is not eliminated, the effects of chloroform are to be feared.

The decision of Volkman goes to show that, especially in the cases of death of children, supposed to be due to shock or "karbolintoxication" after operation, it is due to the chloroform administered.

A case of death four days after operation is quoted. It was circulated at the time that this case died during the operation.

Their aim was (in this research) to ascertain how, and how long the chloroform and its "zersetzungsprodukte" *decomposing* products can be found in the exudations of the body, and especially in the urine.

1. Hegar and Kaltenbach proved, in 1869, that the capability of reduction of the chloroform in the urine does not depend upon glycosuria, but that it was unchanged chloroform in the urine.

2. Zweifel proved chloroform to be present in the urine of the new-born, to whose mother the chloroform had been administered.

3. Kast shares the doubts of Zweifel, whether or not the reducing substance in the urine of the chloroformed subject is unchanged chloroform, particularly as he has tried the "Isonitricreaktion" (the most delicate reagent for the detection of chloroform) in a number of urinary examinations, with but negative results.

They go on to give some of their researches concerning the detection of presence of chloroform, methods, reagents, etc.

Give experiments on animals—rabbits, dogs, etc.—and mode of examination.

The summary goes to show the positive conclusion that pure chloroform is present in the urine, as all the experiments proved, on man as well as on the lower animals.

Gives directions for conducting the examinations, closed receptacles, etc., and attributes the failure to find it, by some researchers, to the fact that the urine is left exposed in vessels for a varying length of time.

THE RESULTS AS OBSERVED IN THE TISSUES.—Fatty degeneration is most common where death is the result of chloroform. Liver first in order of affection, the heart, the other organs variously. It is a fatty degeneration, and *not* a fatty *infiltration*.

Ethel shows same results, though not so marked.

Some Experiments.

CASES 1 and 2.—Two rabbits; chloroformed two days in succession, and killed on the third day by chloroform.

CASE 3.—One rabbit; chloroformed three days in succession; first two days, three hours long; third day, two hours long.

Died eight hours after last narcosis.

CASE 4.—One young dog; three days in succession, two hours each day; narcosis. Fourth day, chloroformed three hours. Died forty-eight hours later (the first twenty-four hours after last administration he appeared well and cheerful).

CASE 5.—A large, strong "zughound;" five hours, successive deep narcosis.

Died next day after one and a half hours' administration.

Sections of the first three (cases 1, 2, 3) showed large, fatty infiltration, a granular cloudiness, besides the beginning of fatty degeneration of liver cells; heart muscle granular, opaque, and beginning to show fatty degeneration.

Rest of organs unchanged.

CASES 6 and 7.—Dogs. Fatty degeneration more marked, especially in the last case. Liver positively white. "Die Lebern sahen geradeso weiss wie die genudelter Gänse aus." Kidney opaque and granular appearance; heart, same appearance, but less marked. Stomach granular and opaque appearance. Other organs unchanged. These examinations proved the liver to be the first organ affected.

He now gives the following case: "Tötliche Nachwirkung des Chloroforms bei einem 36, jährigen Manne 4, Tage nach der Narkose."

Few analogous cases, at least in literature. Quotes Herff. (Sitz.-Ber. der D. Med.-Ztg., 82, 1889).

Müllerknecht Lohde, age 63, strong man, muscular, and up

to 27th September, 1889, 7 P. M., easily carried heavy weights, a sure indication that he was not troubled with any fatty degeneration of heart. His employer gave the information that he was an industrious and reliable man, that he drank but moderately, and was never known to be drunk.

At the above described time he suffered a fracture of the left patella, "Splitterbruch der linken Kniescheibe" (splintered fracture of the patella), while carrying a hundred weight of flour. He fell on a stone step, but got up and carried his load some distance when he broke down.

The same evening a temporary bandage was applied, and he was removed next morning to our institution (9 A.M.).

We found a large hæmorrhage in the knee-joint; entire extremity very much swollen, and intermuscular hæmorrhage. Considerable separation of fragments. Pulse and temperature normal. Pulse, for such a constitution, somewhat soft.

After injection of almost two centigrams of morphia, he was chloroformed with Esmarch's inhaler with "officinal chloroform." We did not use the "chloral chloroform," as we find no advantage in its use; and, furthermore, a recent death occurred by its use at the "Charité."

Patient became much excited, and resented the application for half an hour, during which time he had strong muscular contractions. Chloroform was repeatedly applied, but had no effect, and in the space of seventy minutes we must have used 150 grams of chloroform.

The operation consisted in freeing the hæmorrhage by an incision; of the adaptation of the fracture and suture of the periosteum; bandage of iodoform gauze and sterilized cotton; careful packing of the entire limb, and plaster bandage.

General Condition on Day of Operation.

Temperature, 37.6; pulse, 90, not over strong; delirium at night.

Afternoon of next day much pain in the whole leg.

In the morning, temperature 37.6; in the evening, 38.12; pulse, 90 and 100.

As the plaster bandage was not tight, it was not removed until next day. Patient continues to complain of pain.

Second night, delirious. Leg and wound give same appearance as at the operation. Leg a little more swollen, and shows the well-known ecchymosis. Splints were now substituted. Is now delirious during day. Temperature, 38.0. Pulse, 96; weak, but plainly perceptible. In the evening a marked change, with weakness, and with stronger delirium. From the second day, patient received wine, and cognac and egg (Stockésche mixture), tablespoonful every hour. In the evening, temperature 38.3; pulse 120, wiry and small. After an injection of ether camphor it was better.

Entire night received wine and the Stockésche mixture.

Next morning, pulse barely perceptible at 120; temperature, 37.2. Used injection of ether and other stimulants, and condition becomes more encouraging.

Toward evening, patient pulseless. After an infusion of 1000 grms. of "Kochsalzlösung mit Zuckerzusatz" (common salt solution with sugar) injected in forearm, the pulse appears plainly, and patient more satisfied and cheerful. Directly after the infusion, rapid and deep respiration, after an hour, stertorous. Pulse loses again, and patient dies at 10 P.M. Cardiac failure.

P.M.—Shows exquisite fatty liver, with fatty infiltration and fatty degeneration of liver cells. Liver much enlarged in all lobes. Waxy consistence and no evidence of inflammatory hypertrophy as appears in first stages of cirrhosis. Kidney, stomach and intestine normal. The urine from the cadaver, as also that examined during life, shows, on boiling with Fehling's solution, a deep black precipitate, no indication of sugar, but no "isonitril reaction."

Most marked appearance in the heart. Muscles almost entirely fatty and cross striation barely perceptible. After using acetic acid the muscular fibres (die *muskelschläuche*) remain filled with highly refractive drops of fat. This case shows without doubt fatty degeneration caused by chloroform. Even if the patient were accustomed to the use of whiskey, as the long time necessary for narcosis shows he must have been, the changes of

the organs could not be explained on this theory. They then go on to a consideration of prophylaxis.

Primary Syncope from Chloroform.

In a recent work* received by us from the author, Dr. Robert Kirk, of Edinburgh, states: "The failure (as the writer thinks) of the Hyderabad Commission to throw a single ray of light on the primary syncope from chloroform, which has so often proved fatal in the human subject, has once more prevailed on him to take up his pen in the hope that his views before published may now have a better chance of acceptance, or at all events may lead to investigation in a new direction." The new theory of the author is that there are two forces acting—the chloroform dissolved in the blood, and a further effect due to the vapor in the pulmonary cells. Now the action of the force must be the ordinary anæsthetic effect of the agent, causing retardation and stagnation of the corpuscles in the vessels, and a diminution of all the processes going on there, attended, through reflex action, with corresponding results on the systemic circulation.

"If we suppose that these processes are diminished by a fourth, then the effect may be compared to that of a tourniquet compressing one of the iliac arteries; if by a half, to a similar compression of the abdominal aorta.

"It must be evident that if such be the intensity of the force, its sudden withdrawal will be attended with the liability of syncope, as would be the sudden removal of the tourniquet in the two supposed cases. Now, when the patient is allowed to breathe fresh air, the force ceases to act with remarkable suddenness, for after a few inspirations it is gone. The result is a violent reaction—a violent rebound or whirl of the circulation terminating, in its most pronounced form, in syncope.

"This, and nothing else than this, I believe to be the cause of primary chloroform syncope."

*A New Theory of Chloroform Syncope, pp. 55. Edinburgh and Glasgow. John Menzies, 1890.

Our author's rules are to keep up a continuous atmosphere of vapor until deep anæsthesia is induced, and not to stop short of this point for any reason whatever, no matter what the operation. See p. 44.

There is one point he would stop at; it is when the face assumes a gray-greenish look, which to him is always the danger signal or fatal symptom. A very good hint is to have the apartment heated to 65° or 70° F., and to have two towels or flannel bags thoroughly warmed and dried by the fire.

"If the above theory of the nature of chloroform syncope be correct, it follows that we could illustrate it at will on almost every human being (except perhaps in parturient females and a few others) as we can do on the cat. All that is necessary is to make any one breathe $2\frac{1}{2}$ per cent. of the vapor for a minute or so and suddenly stop short, when the syncope will be almost certain to show itself at the end of the next minute. (See p. 25.)

"This, he states, is exactly what happened in the fatal case (No. 1) of chloroform syncope, in a girl at Winlaton, near Newcastle,* England, who breathed the vapor for a minute and died at the end of the next minute. The other two cases: (2) Patrick C.; age not stated; March, 1848. Disease, fistula; had taken chloroform once previously; time of inhalation about one minute; quantity consumed, half a drachm; lapse of time till death, one minute; patient on his side. Chloroform was administered on a handkerchief or towel. Immediately the operation commenced, the patient became pulseless, his pulse previously being full and natural.

"3. I.V.; aged seventeen; Hotel Den, Lyons, January, 1849. Amputation of finger. Chloroform was dropped upon gauze spread over the face, leaving a free passage of air. At the end of five minutes the patient still felt and spoke; at the end of six minutes he became restless and still spoke. One drachm and a half of chloroform had now been given; pulse regular and good. He now struggled violently, and within a quarter of a minute the pulse at the wrist became imperceptible. The

* London Lancet, Feb. 8, 1890, p. 316.

gauze was removed; no pulse anywhere to be felt and no cardiac sounds audible. Respiration continued and ceased in half a minute. Means of resuscitation were employed, and respiration reappeared in two minutes' time, and then again gradually ceased. The pulse did not return. Our author then states that if his theory does not furnish the true explanation in such cases, there is no other possible theory which can justify us in maintaining that chloroform is a safe agent in all cases, and the doctrine of Simpson and Syme must be erroneous."

The most conclusive statements and experiments are given in the paper of Dr. MacWilliam, in answer to the strictures and conclusions published by Dr. Lawrie.*

"In the *Med. Chron.*, January 1891, Surgeon-Major Lawrie, in an article on the Hyderabad Chloroform Commission, makes some comments on certain results obtained by me in a recent investigation on the action of chloroform and ether, published in the *Brit. M. J.*, October 11, 18 and 25, 1890.

"In my paper I described the frequent occurrence of dilatation of the whole heart under the influence of anæsthetic doses of chloroform. Such dilatation was not due to changes in the pulmonary circuit or to fall of arterial pressure."

Dr. Lawrie urges that the cardiac dilatation *was* due to obstruction of the circulation of the lungs, or to this along with a fall in the blood pressure. He says: "The irregularities in the tracings of the Glasgow Committee, and Prof. MacWilliam's more recent 'bogie' of dilatation of the heart, are due to obstruction of the circulation in the lungs through interference with or irregularity of the respiration." And later: "Obstructed circulation in the lungs and a rapidly falling blood pressure are more than enough to account for the dilatation of the whole heart, which occurred in his experiments, and which he wrongly attributed to the direct action of chloroform."

"Now this hypothesis of Surgeon-Major Lawrie can be briefly and conclusively disposed of. There is an abundance of decisive evidence available. First, as regards the alleged influence of obstruction of the circulation in the lungs in causing dilatation

* Medical Chronicle, Manchester, 1891, xiii., 352–355.

of the heart. In my paper in the *Brit. M. J.*, I stated the fact that such an explanation was incompetent to explain the cardiac condition, since the *whole organ* was dilated in my experiments. Dilatation of the right side of the heart might conceivably (if there were no evidence to the contrary) be accounted for by the presence of pulmonary obstruction. But dilatation of the left side (*e.g.*, the left auricle) could clearly not be accounted for in the same way, since pulmonary obstruction necessarily diminishes in large measure the flow of blood into the left auricle, and this part becomes small and collapsed. This seemed so obvious to me that I did not discuss the matter at any great length.

"I shall now state briefly some facts in regard to Surgeon-Major Lawrie's hypothesis of obstructed circulation in the lungs:

"(1) There is no proof whatever of the occurrence of pulmonary obstruction from the administration in mammals of anæsthetic doses of chloroform sufficiently diluted with air, as was the case in my experiments, the amount of chloroform vapor in the air never exceeding four per cent.

"(2) On the other hand, there is decisive proof that pulmonary obstruction was *not* present in my experiments. Obstruction of the circulation would necessarily cause distension of the pulmonary artery as well as, and indeed earlier than, distension of the right heart. The pulmonary artery would become large and tense in consequence of the increased peripheral resistance to the outflow of blood from that vessel. Then the increased tension would react upon the right heart and cause distension there also. But in my experiments *there was no distension of the pulmonary artery during the administration of chloroform.* The vessel did not become distended; it was soft and compressible, and the tension within it was low. It is quite certain, then, that pulmonary obstruction could not have been the cause of the dilatation even of the right side of the heart.

"(3) Even if pulmonary obstruction had been present—as was not the case—such obstruction could not have produced the condition which I described, or anything at all similar to it.

"I have, on various occasions, purposely brought about a condition of pulmonary obstruction by mechanical means with a view to studying the features of this condition. This I did by injecting into one of the great systemic veins some particulate substance, *e.g.*, lycopodium powder, which would cause embolism of the pulmonary vessels, and so obstruct the circulation in the lungs. When such a substance is injected into the vein, it rapidly passes through the right heart into the pulmonary vessels, speedily causing more or less extensive and sudden obstruction of the pulmonary circulation, according to the amount and suddenness of the injection.

"The effects resulting from the plugging of the minute pulmonary vessels induced in this way are very noteworthy, and illustrate clearly the consequences of obstruction of the circulation in the lungs. The pulmonary artery swells up and becomes largely distended, while at the same time the vessel feels hard and tense to the touch; the pressure within the vessel is greatly elevated. The right ventricle and the right auricle then partake in the condition of distension, being unable to discharge their contents in the normal fashion in face of the greatly augmented resistance in front. The lungs become pale and anæmic.

"Meanwhile, it is important to observe that the left auricle becomes small and collapsed-looking in consequence of the obstacle offered to the passage of the blood through the lungs. Strong respiratory efforts, with convulsions of the asphyxial type (accompanied by spasmodic contraction of the systemic arteries), supervene in consequence of the stoppage of the respiratory purification of the blood; the medullary centres become violently stimulated by the venous character of the blood. Death speedily follows.

"It is unnecessary to enter closely into a comparison, or rather contrast, of the typical illustration of pulmonary obstruction here afforded, and the condition of cardiac dilatation which I have described as occurring under the influence of chloroform. It is obvious that obstruction of the circulation in the lungs produces changes strikingly different from those that result from the action of chloroform; and that the hypothesis of pulmonary

obstruction may at once be dismissed as entirely insufficient and inapplicable, as far as an explanation of the cardiac dilatation occurring under chloroform is concerned.

"Seeing that it is easy to dispose of the question of pulmonary obstruction in regard to the effects of chloroform upon the heart, I shall now advert briefly to the possibility of cardiac dilatation being dependent on a rapidly falling blood-pressure, as alleged by Dr. Lawrie.

"This is a matter which I carefully considered in my paper, and in regard to which I was able to state definitely that the cardiac dilatation is *not* due to a fall of blood-pressure. This is conclusively proved by the following facts: (1) Dilatation of the heart does not by any means always run parallel to the fall of pressure which ordinarily results from the administration of chloroform. Sometimes there is a very marked fall of pressure, with little or no dilatation of the heart; while at other times the heart begins to dilate before the pressure begins to fall. (2) Moreover, the heart in some instances begins to dilate during the temporary *rise* of pressure which at times precedes the fall. (3) Further, there may be distinct dilatation of the heart without any change of pressure at all. (4) Lastly, it can easily be shown that a simple fall of pressure, equal in amount to that which ordinarily occurs under chloroform, induced by means which do not directly affect the heart (*e.g.*, section of a vaso-motor nerve, hæmorrhage, etc.), does not cause dilatation of the organ, as chloroform does.

"It is clear, then, that the dilatation of the heart brought about by chloroform cannot be due to obstruction of the circulation in the lungs, or to a fall of systemic blood-pressure; it must result from a depressing influence exerted by the anæsthetic on the organ (1) directly, or (2) through the vagus nerves.

"Finally, as this depressing influence, leading to dilatation, is readily manifested after section of both vagi, it is obvious that chloroform must act upon the heart directly.

"I cannot help feeling that even a comparatively slight amount of *actual observation* of the features and results of a simple lowering of the blood-pressure and of *real* pulmonary obstruc-

tion would have prevented Surgeon-Major Lawrie from putting forward and adhering to such a hypothesis as I have here discussed—a hypothesis at once insufficient, absolutely untenable, and in conflict with large and somewhat elementary facts in the physiology of the circulation."*

CHAPTER X.

Chloroform in Dental Surgery.

A valuable communication has been received from Frederic Hewitt, M.D. (anæsthetist to three of the London hospitals), giving his views of chloroform as an anæsthetic, and more especially in dental surgery. It is almost the united opinion both of the medical and dental profession, in this connection, that chloroform is too dangerous an agent to employ, especially in the extraction of teeth. Dr. Hewitt's knowledge and long experience should give his opinion on this subject great influence with the dental profession. The paper was read in the city of Edinburgh, where chloroform is held in such high favor, and before the British Dental Association as late as August, 1895.

I. Introducing the subject, he states: "Under what circumstances should chloroform be employed as an anæsthetic in dental surgery? For many years past every member of the medical and dental professions, indeed I may say every thoughtful individual throughout the civilized world, has been awaiting some authoritative statement on this subject. Although the conservative dentistry of recent years has dealt a salutary blow at the reckless removal of decayed teeth, the operation of tooth extraction is undoubtedly necessary in some millions of cases annually, and with this necessity for tooth extraction

* In reply to Lawrie on the Hyderabad Chloroform Commission. Same journal, 1891, xiii., 276–279, ch. i.

there is naturally enough demand for the painless performance of these operations. It therefore seems to me that it is clearly the duty of the dental profession to possess some established and recognized principles for the guidance of its members in this important part of their practice. Any one who administers a general anæsthetic for a surgical operation takes upon himself a responsibility that is too often lightly estimated. The life of the patient, for the time being, is completely delivered into his hands. Prolonged practice with the most lethal anæsthetics may give the administrator of them a kind of contempt for their dangers, but the dangers, although doubtless lessened by the capabilities of such anæsthetics, are nevertheless present. Now, with regard to the selection of appropriate anæsthetics for the comparatively trifling operation of tooth extraction, there should be absolute unanimity.

"There are several reasons for the present occasion being a particularly auspicious one for the discussion of this subject. In the first place there can be no doubt that within the past few years we have become possessed of many fresh physiological data concerning the action of chloroform. In the next place, the columns of periodicals specially devoted to advancement in dental science have for some time past been frequently occupied by notices of deaths under chloroform and by warning editorial articles."

II. The Lines Upon Which the Inquiry Has Been Conducted.

"Let me now briefly explain the lines upon which the present inquiry is based. I have taken a period of fifteen years, *i.e.*, from 1880–1894 inclusive, and I have exerted every means in my power to obtain particulars of all fatalities which have occurred during this period in Great Britain, in connection with the use of anæsthetics for dental operations. It seemed advisable to take a definite period of time, and I fixed this at fifteen years, partly because I have myself collected records of deaths under anæsthetics for this period; partly because within the past ten or fifteen years the records of deaths under anæsthetics have become fuller and more reliable than they formerly were,

and partly because by analyzing recent cases one is more likely to obtain additional information to that already published, than when dealing with long-forgotten casualties.

"I very much regret to say, however, that although by the system of inquiry which has been followed, several cases have been brought to light which were hitherto unavailable for consideration, and numerous facts in connection with already recorded cases have been elicited, there is much ground for the belief that the inquiry by no means includes *every* fatality which has occurred in Great Britain during the past fifteen years. Even in England, where coroners' inquests are invariably held when a patient dies under an anæsthetic administered for a dental operation, the facts of the case may never pass beyond the coroner's court, or the columns of some obscure local paper. But in Scotland, where coroners' inquests are unknown, a comparatively large number of cases must necessarily elude the vigilance of an inquiry such as the present. When I had satisfied myself that I had obtained as many records as time and other circumstances would permit, I proceeded to classify and analyze the cases in the manner I shall now describe."

III.—Classification and Analysis of Cases.

"The following table (Table I.) shows the total number of cases of which records could be obtained.

"There are certain interesting points in connection with this table to which I shall now refer. In the first place, we cannot but be struck by the fact that in Great Britain no less, and in all probability considerably more, than 37 persons have died in connection with the use of general anæsthetics for dental operations during the past fifteen years. In the second place, we find that out of this total of 37 fatal cases no less than 27 occurred in connection with the use of chloroform; and that if we include the chloroform-and-morphine case, the chloroform-and-ether case, and the 2 cases which arose in connection with the use of the so-called 'methylene' (which experience has shown to consist largely of chloroform), we may say that of the 37 cases no less than 31 took place in association with the use either of chloroform or some combination containing chloroform. In the third

place, we note there is only one recorded ether fatality. I have made careful inquiries as to this one case, and, without entering into detail here, I may say that it should properly be excluded from the table, for not only was the patient in such a condition of health that the administration of any anæsthetic at the time was extremely hazardous, but death arose from mechanical asphyxia, principally due to a cancerous growth of the mouth, and possibly also to the entrance of blood into the larynx. In the fourth place, I would remark, in connection with the nitrous oxide fatalities, that one of them occurred from the entrance of an extracted tooth into the larynx. But, as in the ether case, I have added this, so that it may be said that every possible case has been included.

TABLE I.—*Deaths in Connection with General Anæsthetics Administered for Dental Operations in Great Britain* (1880–1894, *inclusive*) = 37.

Anæsthetic Used.	Scotland.	England and Wales (excluding London).	London.
	Approximate Population (Average Between Census of 1881 and 1891) = 4 Millions.	Approximate Population (Average Between Census of 1881 and 1891) = 23¼ Millions.	Approximate Population (Average Between Census of 1881 and 1891) = 4¼ Millions.
Series 1. Chloroform	12	15	0
" 2. Chloroform, followed by subcutaneous injection of morphine	1	0	0
" 3. Chloroform 3 parts, ether 1 part, in mixture	0	1	0
" 4. "Methylene"	0	2	0
" 5. Ether	0	1	0
" 6. Nitrous oxide gas	1	2	2
	14	21	2

"We next pass to a fuller consideration of the chloroform

fatalities themselves. These, 27 in number, I have arranged in two groups, viz.:

"*Group* 1.—Cases reported with sufficient fulness to admit of comparisons and analyses being made of them; and

"*Group* 2.—Cases with sufficient data to admit of any such classification or analysis."

(We have had to omit the table for want of space.)

"I may say, however, that no case has been included in this group unless it is to be found reported in one of the leading medical or dental journals, or unless I have been able to thoroughly satisfy myself, through the medium of correspondents, that it actually took place. Should any doubt exist in any one's mind as to these cases I shall be much pleased to place my references at his disposal."

Sex.

"Of the 19 cases 5 were males and 14 females. This preponderance of female over male patients is to be explained by the fact, with which all dental practitioners must be familiar, that the great majority of those who require anæsthetics for dental operations are women. . . . . Women and children are the best subjects for chloroform, and I have no hesitation in saying that if men of vigorous build constituted the majority of patients requiring anæsthetics for dental operations, the number of accidents under chloroform would be even greater than at present."

Age.

"Most of the patients were young, the highest recorded age being 37, the lowest 8 to 10 years. This is again to be explained by the reasons which I have just given."

General Condition.

"Taken collectively, there was no case with any condition which precluded the use of an anæsthetic or which rendered anæsthesia perilous. Experience has now convinced most thoughtful observers that the presence of a 'weak heart,' or, in fact, the existence of cardiac disease, in no way contra-indicates the employment of an appropriate anæsthetic."

Preparation.

"Nothing is said as to the regulation of the diet or looseness of the attire in nine of the nineteen cases. Of the remaining ten there is evidence of the diet having been regulated in six cases, and of the attire having been loosened before the administration in five. In only two cases is there a note of both of these precautions having been adopted. In one case there is evidence that no precautions were taken at all; in fact, the patient was attired in a tight-fitting new dress."

Posture.

". . . . Thus we find that in one case the patient was in the sitting posture; in three cases in the sitting or semi-recumbent posture; in three cases in the semi-recumbent posture; in one in the semi-recumbent or dorsal posture; and in four cases in the dorsal posture. In other words, there is evidence that the patient was either sitting or semi-recumbent in seven of the twelve cases in which any details as to posture are given.

"The posture of a patient during the administration of chloroform for a dental operation is a matter to which attention should be carefully directed. Most medical and dental practitioners are aware of the influence which a more or less vertical position of the body may exert upon the circulation—effects which are directly dependent upon the force of gravity. But there would appear to be comparatively few who fully realize the fact that in dental operations generally, and more particularly in dental operations under chloroform, the circumstances which usually attend the administration of the anæsthetic are very favorable to the occurrence of arrested breathing. It will be well to say something as to the effects of posture upon the circulation.

"A very complete research by Dr. Leonard Hill, communicated not long ago to the Royal Society, is of importance in this connection. Dr. Hill finds the circulation in the lower animals to be directly influenced by the force of gravity, the arterial tension in the carotid arteries rising in the feet-up and falling in the feet-down posture. He further finds that the splanchnic vaso-motor mechanism, which regulates the quantity

of blood in the splanchnic area, compensates for these changes in the tension of the carotids, and that, when the mechanism is intact, and the heart is acting efficiently, raising the trunk and lowering the feet has no dangerous effect upon the circulation, for by the constricting action of the splanchnic mechanism, blood is prevented from accumulating in the splanchnic area and the heart, and therefore the carotids and the brain are kept properly supplied. But if the splanchnic vaso-motor mechanism be damaged, as, for example, by the use of large quantities of chloroform, by asphyxia, or by other causes, an alarming and perhaps fatal attack of syncope may attend elevation of the trunk, for the splanchnic area is full of blood, and the arterial system is comparatively empty. Dr. Hill lays stress, too, on the fact that if the heart's action has become depressed from an overdose of chloroform or other causes, this elevation of the trunk will be even more liable to end disastrously. But should the patient's circulation be extremely feeble (from nervous apprehension, functional or organic disease, anæmia, etc.), before the administration, or should it become greatly depressed (from the use of too small or of too large quantities of the anæsthetic, from vomiting, from asphyxial complications, or from surgical shock) during the administration, any elevation of the trunk from the horizontal plane may certainly be fraught with considerable danger.

"EXTENSION OF THE HEAD AND NECK.—It is a common practice in dental surgery for the head to be thrown well backwards upon the trunk in order to allow of the extraction of upper teeth. This procedure, however, has the effect of bringing the base of the tongue and epiglottis away from the pharynx and larynx respectively, so that the act of swallowing is rendered difficult or impossible. Any one may satisfy himself with regard to this point by making the experiment upon his own person.

"When extension of the head and neck is practiced during *deep* anæsthesia, another danger comes into operation, viz., that of foreign substances actually entering the now insensitive, open, and unprotected larynx."

FLEXION OF THE HEAD UPON THE STERNUM. OPENING THE

MOUTH VERY WIDELY BY MEANS OF PROPS OR GAGS.—By placing one or more pillows under the head, without raising the shoulders, the tongue will tend to touch the pharyngeal wall, and the breathing may thus become impeded, stertor passing into complete obstruction. This was pointed out by Bowles. A similar state of things may arise during the extraction of lower teeth, respiration completely ceasing so long as the lower jaw is driven down towards the sternum. Again, if the mouth be opened very widely by a prop or a gag, respiration will be liable to become arrested when the patient is anæsthetized, the depression of the lower jaw having the same effect in approximating the tongue to the pharynx as when the whole head is flexed by means of pillows.

In the semi-recumbent and dorsal postures the tongue may, during properly established anæsthesia, gravitate towards the pharyngeal wall and obstruct breathing. I have frequently demonstrated at the Dental Hospital the great difference, in regard to the occurrence of obstructive stertor, between a nearly vertical posture and a position approaching the semi-recumbent—the latter being a very favorite one for dental operations. I am now speaking of nitrous oxide cases, but the remarks apply to chloroform. When the body and head are nearly vertical the tongue rests on the floor of the mouth, and obstructive stertor is not likely to arise. When the body and head are thrown more backwards, as they almost invariably are when chloroform is about to be given, tongue-stertor is far more likely to arise, and respiration to become embarrassed from this cause.

Method of Administration and Quantity of Chloroform Used.

In 5 of the 19 cases no particulars are obtainable concerning the method adopted or the quantity of chloroform used. The method is referred to in 13 cases. In 3 of these a Skinner's mask was employed ; in 2 a folded napkin ; in 2 a piece of lint; in 2 a "napkin" (? folded or not); in 1 a towel ; in 1 an "open inhaler;" in 1 a Junker's apparatus ; and in 1 it is stated that the chloroform was administered "in the usual way." The

quantity of chloroform used is given in 6 of the cases. The smallest quantity was half a drachm; the largest was a little over 2 drachms. If we take "a little over"—an expression used in 2 of the cases—to mean 20 minims, and if we reckon 45 minims to have been employed in the case in which "40 to 50 minims" is mentioned, the average quantity of chloroform used in these 6 fatal cases works out at about $2\frac{1}{2}$ drachms. Special reference will subsequently be made to the 2 remarkable cases in which only 30 minims and 40 to 50 minims respectively were employed.

Nature of Operation.

The proposed operation is not stated in 5 of the 19 cases; in 1 it is said that a "large number of roots" had to be removed; in 4 cases "several teeth" are referred to; in 1 case eighteen roots had to be extracted; in 2 cases nine teeth; in 2 cases six teeth; in 1 case the roots of one tooth and then two entire teeth; in 1 case three teeth; in 1 case one tooth and one stump; and in 1 case one tooth only.

Relation of Dangerous Symptoms to Operation.

In 3 cases the dangerous symptoms arose before the operation; in 8 during; in 2 during or after; in 5 after; and in 1 it is impossible to say at what juncture they occurred.

Phenomena During Administration and Operation. Fatal Phenomena.

"The occurrence of dangerous symptoms during the administration of an anæsthetic for the comparatively minor operation of tooth extraction is usually so disturbing that a clear and systematic statement is next to impossible.

"For example, breathing may so noiselessly and insidiously cease that the cessation may readily escape detection, the more so as thoracic and abdominal movements may continue even when there is complete obstruction to the entry and exit of air to and from the chest.

"Amongst the 19 fatal cases there are no less than 6 (viz., Nos. 2, 9, 10, 15, 16 and 18) in which chloroform was readmin-

istered during the operation—a fact which corroborates the opinion that this readministration in dental surgery is hazardous unless skilfully conducted.

"Chloroform is administered in very small quantities at a time, as I have often seen it administered, and a highly unsatisfactory state of affairs results. I believe Syme's dictum was that 'drachms may save whilst drops may kill,' and there is a good deal of truth in this remark. When chloroform is given in too small quantities at a time, and delay arises in producing surgical anæsthesia, the circulation will often show signs of running down. Pallor, feeble pulse, shallow and almost imperceptible breathing will arise. An experienced administrator, taking in hand such a case at such a time, would add half a drachm, a drachm or even more of the anæsthetic to the lint, and apply the latter more closely to the face, with the result that respiration would quickly increase in force."

Post-Mortem.

"Nothing is said as to any *post-mortem* having been performed in 8 of the cases. In 4 it is stated that no autopsy was made. In the remaining 7 cases the particulars obtainable are so imperfect and meagre that no useful purpose would be served in classifying them."

We regret we cannot give the whole of this pamphlet (32 pages), but have endeavored to give a full abstract and the latter portion.

CHAPTER XI.

Anæsthesia by Chloroform and Oxygen.

In our third edition (p. 474) it is there stated and published, in 1887,* that Dr. Kreutzmann, of San Francisco, employed not the pure chloroform, but Billroth's mixture (three parts of ether to one of chloroform) in conjunction with oxygen. The

* Pacific Medical and Surgical Journal, August, 1887.

discoverer of this method was Dr. Neudorfer, of Vienna, who claims on theoretical grounds that its employment is entirely without danger. We also published in the same edition (p. 210), 1890, the following case, illustrating the fact that

Oxygen Was an Antidote to Chloroform.

"A young man attached to the laboratory of the New York Medical College became asphxiated from the inhalation of the vapor of chloroform; and so far had its effects been carried that he became pulseless, and all hopes of his resuscitation abandoned; and as all the usually recommended remedies had been tried without success, nothing but the death of the young man was looked for, when I proposed, as a *dernier resort*, the application of pure oxygen gas, as the only chance by which resuscitation could be brought about; but at the time the proposal met with opposition from the medical men present, who were anxiously watching what seemed to be the expiring efforts of the poor boy, expecting each moment to be his last. Having, however, consented, the gas had not been more than a few seconds applied to his nostrils, when he who was apparently beyond the help of human skill, and absolutely *in articulo mortis*, arose and placed himself upon a chair, proving most conclusively how correct I was in proposing the application of oxygen gas as a remedy against the deleterious effects of chloroform as an anæsthetic."—*Dr. Simeon Abrahams.*

I also published the following facts in corroboration of the great value of oxygen gas:

"Dr. Loyssel has experimented with pure oxygen and from it has obtained very good results. He concludes:

"1st. That in certain poisonings, such as those by *chloroform*, *ether*, opium, sulphuretted hydrogen, carbon dioxide, cyanhydric acid, oxygen constitutes the only means of recalling the patient to life, when all else has failed.

"2d. That its presence in the operating room is certain protection against fatal accidents from the use of anæsthetics.

"3d. That it succeeds equally well in asphyxia, caused by strangulation, by immersion, by toxic gases, etc., as well as with the new-born, in condition of apparent death.

"4th. Life can almost, with certainty, be maintained in all cases where respiration has not entirely ceased, even if there are long intervals between the inspiratory efforts.

"5th. If the respiratory and circulatory functions have been completely arrested for a short time, they may be re-established by means of oxygen, which it is necessary to administer with perseverance, even when it is believed that all efforts will be useless. There are reported many cases of drowned persons, and of children apparently dead, who have been saved, thanks to persistence in administering oxygen.

"6th. Oxygen may be inhaled in notable quantity without the least danger."

On page 202 were given a number of careful experiments to determine if it were an anæsthetic, and concluded that pure oxygen was not a true anæsthetic, but could be inhaled with safety even in large quantities.

In February, 1895, was published a valuable communication by Dr. H. L. Northrop, giving his reasons for the administration of oxygen with chloroform when the latter is used as an anæsthetic, and he premised by stating that he had administered it in one hundred operations, from the most minor to laparotomy, for hæmatoma, amputation of breast, celiotomy for ruptured liver, herniotomy, amputation of leg, and several cases of appendicitis :

"The idea of combining oxygen with chloroform for anæsthetic purposes occurred to me a year and a half ago, while considering the physiological effects of chloroform. Since then I have demonstrated its practical utility.

"A search was made for me in the Patent Office at Washington ; I have examined the Index Medicus for the past five years for articles bearing upon the subject, and I wrote to London hospitals and received a reply.* From none of these sources could I learn of anything in regard to this combination. Thus it would appear that this is the first instance in which oxygenated chloroform has ever been used.

* This is the old idea to go abroad for what can be found at home.

"Function must go on even during the anæsthetic state, though, of course, it is depressed and limited—in the first place by the presence in the blood of a virulent poison, and in the second place because both the cerebro-spinal and sympathetic nervous systems are *partially* overpowered and cannot continue their work. I say partially overpowered, because it is the sensory and motor nerves of the cerebro-spinal system which, so far as we know, are most deeply and prominently poisoned. To prove this statement, the nerve-centres of the cerebro-spinal system governing the respiratory and circulatory functions are *not* involved in the poisoning unless a lethal dose be administered, while at the same time we have a more or less complete paralysis (if you please) of all the other motor and sensory nerves. Again, to aid in maintaining the circulation, we must have a continuance of vaso-motor influence, and this must be, and is, supplied by the sympathetic nervous system.

"This satisfactorily proves that certain functions are carried on to some extent even during the anæsthetic state. To just *what* extent function is carried on it is impossible to say, and, in fact, it is not at all necessary for us to know. Function depends upon the oxidation of tissue; oxygen is the oxidizing agent of the body. Anything that lessens the supply of oxygen to the animal body will interfere with its functions. The extent to which function is interfered with depends, of course, upon how much the supply of oxygen is lessened. It is certain, therefore, that we *must* have oxygen in sufficient amount if function—and, therefore, existence, life, vitality—is to be maintained.

"Why is chloroform such a deadly anæsthetic? Why have thousands of dollars been expended and thousands of animals been sacrificed, and Hyderabad and Glasgow Commissions been appointed? Why have medical men argued and debated with one another, vainly trying to solve this momentous question? Is it not all for the purpose of trying to determine *why* chloroform kills, and to find a safer method for its administration?

"The vapor of chloroform is very heavy—more than four times as heavy as atmospheric air. Because of its weight, when administered by the open method, atmospheric air is

partially excluded, and therefore the amount of oxygen absorbed is diminished. If the air is mixed with chloroform mechanically, as by the Junker inhaler, we even then have the amount of oxygen absorbed reduced one-half, and, of course, this is replaced by the absorption of an equal weight of chloroform. If the chloroform be given in a more concentrated vapor, its weight is sufficient to prevent the absorption of oxygen altogether, and death follows, in great part, from complete deprivation of oxygen.

"We have seen that oxygen is necessary for the maintenance of function; function is necessary if life exists; chloroform, by the weight of its vapor and by the physical laws governing the arrangement and absorption of gases, displaces the oxygen and reduces the quantity absorbed one-half, even if the atmospheric air be freely mixed with it.

"Chloroform, by its weight, falls into the deepest and ultimate air-vesicles; hence it is brought into close contact with the blood, and rapid absorption is favored. This, of necessity, potently tends to surcharge the blood with chloroform and to displace or decrease the normal amount of oxygen, and interferes with oxidation, upon which function depends. For this reason our patient's life is endangered, and that is why, also, pure oxygen should be mechanically mixed with the vapor of chloroform."

Mr. President: Your Anæsthetic Commission* begs leave to make its final report upon the experiments with chloroform and oxygen, presenting to you the data of 100 cases, with a few observations and practical conclusions as the outcome of our work.

We preface our tabulated list of cases by stating that all of our patients underwent a careful preliminary physical examination as regards heart, lungs and kidneys, the result of the same being noted on anæsthetic blanks.

Squibb's chloroform was used, and the oxygen was contained, under pressure, in iron cylinders, each of which held forty gal-

* Formal report of the Anæsthetic Commission, of which Dr. H. S. Northrop was chairman.

lons. The oxygen was passed through the chloroform, the vapor thus formed conveyed to a mask or inhaler, which was made to fit closely around the patient's mouth and nose. The inhaler was provided with a valve for admitting or excluding atmospheric air, and a rubber bag, into which the patient exhaled when the valve was closed. This simple form of apparatus was found convenient, portable and easily managed and controlled.

Complete anæsthesia was produced, as a rule, in a shorter time than can be done by ether or chloroform. The shortest time required to bring about complete anæsthesia with oxygenated chloroform was one-half minute, in one case, and the longest time 10 minutes. (The latter case was an alcoholic, and one of our earlier cases, when we were not well acquainted with our anæsthetic.) The average time consumed in anæsthetizing each case was $4\frac{7}{100}$ minutes, which average is probably lower than any yet published for ether or chloroform administered by the open method, and possibly lower than any for the closed inhalers (Clover and Junker).

The quantity of chloroform used in many of the cases was certainly insignificant, and, of course, the amount of oxygen consumed must have been in direct proportion to the quantity of chloroform vaporized. We could not ascertain the quantity of oxygen used in each case ; one cylinder, however, lasted for about six hours of anæsthetizing.

One of the most prominent (and, we must say, pleasing and satisfactory) conditions attending the use of oxygenated chloroform was a rosy color and healthful blush of the lips and cheeks, and a bright red oxygenated state of the blood flowing from a wound. These apparent expressions of good æration were noticed by many by-standers, and are worthy of note because of the contrast presented to the well-known, death-like pallor attending the use of chloroform alone.

Vomiting occurred in about 30 per cent. (or less) of the cases. It has usually been of short duration, consisting of a watery, greenish fluid (bile and mucus), and only an ounce or two to each case so affected. Some of our patients had slight, temporary nausea, others merely retching without vomiting, and, as

above stated, about 30 per cent. vomited. Frequently retching occurred while the patient was on the operating table. This was immediately and successfully controlled in all cases by turning on the current of oxygenated chloroform.

In the matter of vomiting our anæsthetic was put to a pretty good test. More than a year ago Dr. I. G. Smedley removed the ovaries of a woman who was anæsthetized with ether. She vomited persistently for one week and her general condition became seriously imperiled. Previously to this her cervix and perinæum were restored by the late Dr. Goodell, of this city. Ether was given this time also, and she vomited for 9 days after the operation. She was a case on our list, nephroraphy having been performed by Dr. W. B. Van Lennep. Our notes say: "Conscious in 10 minutes after placed in bed at 3 P.M. No vomiting until after 9 P.M., when cracked ice was given. Vomiting of a thin, greenish fluid in mouthful quantities at intervals all night." The next morning the patient's stomach and liver were quiet, and remained so, an uneventful recovery following.

Oxygenated chloroform usually slows the pulse, and the more deeply the patient is anæsthetized the more slowly the heart beats, but the pulse is full and strong. The respirations are apparently not affected. The respiratory movements are certainly not labored or excited, though in one or two cases the respirations were irregular, at one time fast, at another slow.

Recovery takes place very quickly, our patients often being wide awake in 10 or 15 minutes after they are placed in bed, and almost invariably without any delirium or sign of intoxication. As an exception to the statement just made, Case 10, a minister, required four people to hold him in bed for the first 10 or 15 minutes following his operation.

I have received, February 20, 1896, a more recent and careful description of the arrangement for the administration of chloroform and oxygen.

Dr. Northrop states: "It gives me pleasure to make known the favor with which chloroform and oxygen, as an anæsthetic, has been received, to lay down a few explicit rules for its administration and to now describe a new apparatus.

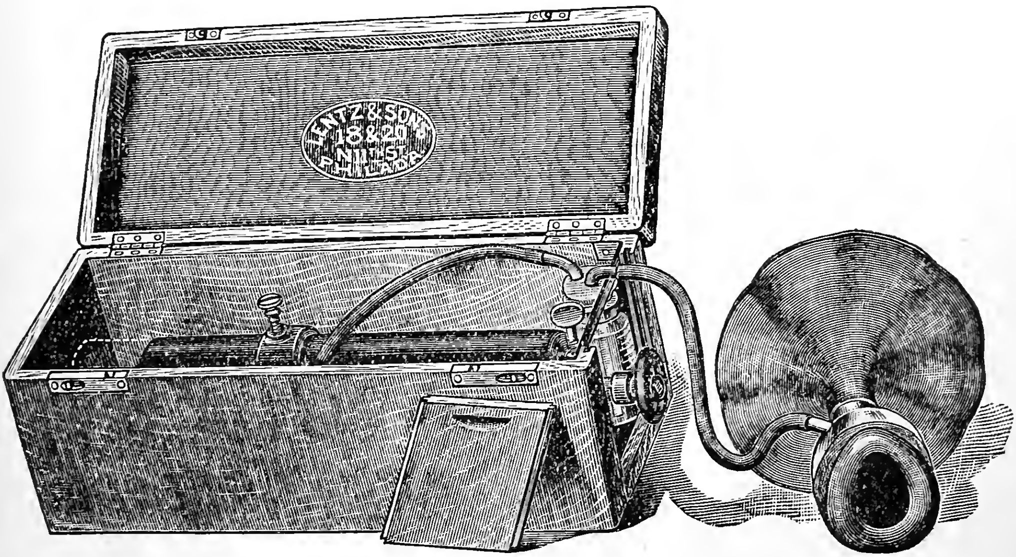
"I wish to publicly thank Dr. J. H. McClelland, of Pittsburg,

for the unreserved and valuable endorsement he has given this anæsthetic, after the most thorough tests.

"This article is prompted by a feeling of its necessity at the present time, in view of the fact that frequent inquiries are made of me in regard to 'C. & O.' apparatus. The apparatus can now be bought of Charles Lentz & Sons, 18 North Eleventh Street, Philadelphia, and has received my final approval."

The following, Plate 48, is an illustration of oxygenated chloroform apparatus.

Plate 48.



"It is arranged in a nicely polished wooden box, 18 inches long, 7 inches wide, 7 inches deep, contains a steel cylinder holding 40 gallons of pure oxygen, a graduated 2-ounce bottle, the requisite length of rubber tubing and the inhaler. The latter has an inflatable face-shield attached to a metallic hood, with which is also connected a rubber respiratory bag. This, with the small wheel to be attached to the cylinder, the perforated rubber cork and nickel-plated brass tubes, is all the apparatus necessary for the proper administration of chloroform and oxygen. One may (and should) also keep in his C. & O. box

one (or two) quarter-pound cans of ether, a folding Allis ether inhaler, a hypodermic syringe, proper stimulants, a pair of vulsella forceps and an infusion apparatus. A mouth-gag will be added to the above list by those who desire it. The apparatus weighs 19¾ pounds.

"In order to use the apparatus put two ounces of pure chloroform into the bottle, attach the tubes to the cylinder and perforated cork, and place the bottle in the corner near the open end of the box, passing the tube leading to the inhaler through this opening. Pull out the cylinder until it touches the bottle and fix it in position by tightening the screw in the top of the iron ring supporting the cylinder. Put the wheel on the cylinder valve, close and fasten the lid of the box, and the apparatus is ready.

"It is my custom to place the box on the left side of the patient, upon the bed or operating table, or upon a high stool or small table, if its position beside the patient would interfere with the operation.

"In administering the anæsthetic turn the wheel *carefully* until a gentle but continuous current of oxygen bubbles up through the chloroform, and apply the mask directly to the patient's face, *making it fit tightly.* The oxygenated chloroform vapor at this stage is not (should not be) concentrated enough to disturb the equilibrium of the patient's respirations. All anæsthetists know that the deeper and fuller the subject breathes the more easily and rapidly will a state of narcosis be produced. The same holds good when employing chloroform and oxygen. As the patient approaches the unconscious state turn on a slightly stronger current of oxygen, and if the stage of rigidity ensue (it is very frequently absent) a still stronger current should be used.

"It is sometimes possible to begin anæsthesia with a moderately strong current, to continue the same until complete relaxation is produced, and this without causing a ripple of disturbance in the patient's respiratory or cardiac functions. Several times it has been my surprise (and pleasure) to find my patient completely relaxed and ready for operation while I was waiting for a stage of rigidity.

"I have found that complete relaxation and puffing breathing, which are characteristic of deep anæsthesia, prevail at first, even though the cornea be not insensitive. The latter indication of the full anæsthetic state will come later; but do not wait for it before notifying the operator to begin. Continue the inhalation, and, *as a rule*, the cornea will shortly become anæsthetic. I say as a rule, for sometimes it seems impossible to bring about its insensitiveness. Here the patient is usually a male, probably an alcoholic, large, muscular, 'bull-necked.' But simply having a sensitive cornea does not mean that he is not ready for operation. Experience has proved that he is and that he will not resist surgical interference.

"Further demands for C. & O. are made in the same way as for any anæsthetic. Resistance upon the part of the patient, recurring sensitiveness of the cornea, attempts to vomit, etc., all indicate a renewal of the inhalations. It is my habit to leave the inhaler in position, even though the current be turned off. And as long as the mixture is being inhaled I watch the cornea and pupil particularly and feel the pulse *at the wrist* occasionally. The wrist is, in my opinion, the only place to satisfactorily test the heart's action. If the cornea is totally insensitive, and especially if the pupil is enlarging, turn off the oxygen. Watch for the return of the sensitiveness of the cornea, and in a few minutes it will be found. Inhalations need not be renewed immediately, however. The anæsthetist must use his own judgment here, and at all times, as to the quantity of the anæsthetic to be employed.

"Should retching occur and vomiting threaten, administer a fairly concentrated vapor, at the same time encouraging the patient to breathe, which can be done by keeping the jaw well raised. This will be found effectual in bringing about relaxation of the diaphragm and abdominal muscles.

"In case of collapse it may be thought advisable to remove the long rubber tube from the chloroform bottle and attach it to the cylinder in order to administer pure oxygen to the collapsed subject. It will perhaps be necessary to pull out the tongue and perform artificial respiration at the same time.

"I advise each possessor of a C. & O. apparatus to carry a

piece of paper in the box, and to regularly note the date and length of operation, thus keeping a record of the duration of time the cylinder is used. Let him also number each cylinder upon the label near the end, and so be able to determine approximately the amount of oxygen it contains, and accordingly the length of time it should last. I have found a cylinder to furnish oxygen enough for from four to six hours of operating.

"Let me again caution the anæsthetist not to waste the oxygen. When not desiring to make the patient inhale the vapor, turn off the current completely, even though the inhaler be left in position. It requires but the *slightest* turn of the wheel to furnish a current of the proper strength."

Chloroform and Oxygen.

The most recent observations in regard to the efficiency of the anæsthetics, chloroform and oxygen, Dr. Northrop reported a few months ago, and Dr. Hassler* has had the same good results since that report. The number of cases during the year, 254 having vomited following its use is but 9.5 per cent., occurring mostly in alcoholic and intestinal operations. The shortest time to complete anæsthesia was 48 seconds, and the longest 12 minutes, in a hysterical woman. The smallest amount used was three drachms in seventy minutes for the operation of colototomy, for removal of both ovaries. Ether has been given more frequently than any other anæsthetic.

The same authority states that "chloroform has been restricted to children, alcoholics and short operations." In this year's report they only employed nitrous oxide in one case.

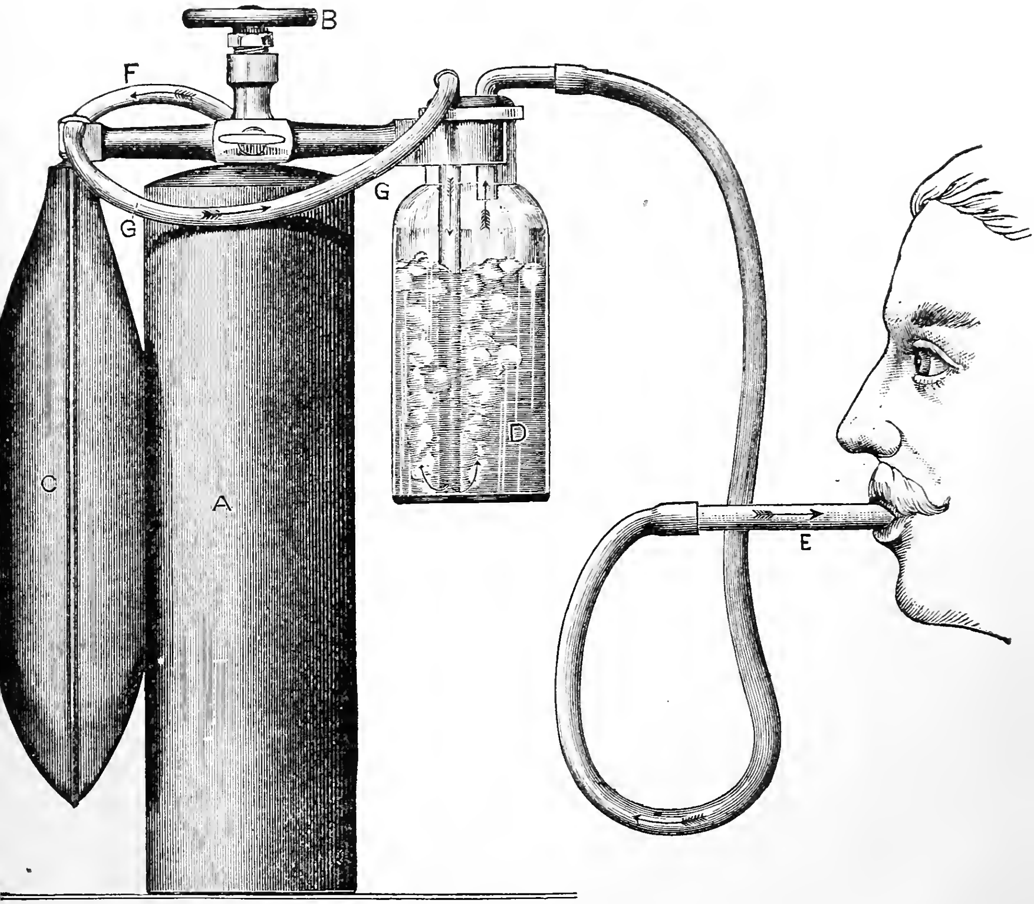
Upon inquiry among the surgeons of all the schools in Philadelphia I find but only one or two who have employed chloroform and oxygen to any extent; indeed, only one. Professor Montgomery has used it extensively in his operations. But I find they all have it at hand for use after extensive operations in case of any indication of very weak pulse and respiration.

* "A Year's Work of Anæsthetizing 370 Cases in Dr. Northrop's Hospital," March, 1896.

Oxygen-Inhaling Apparatus.

A very useful apparatus is that devised by the S. S. White Co.; the administration is absolutely under the control of any intelligent individual.

PLATE 49.



The inhalation apparatus will be seen in Plate 49, and is a modification of the nitrous oxide apparatus.

A represents the cylinder filled with compressed oxygen gas into a liquid; B, the gas valve; C, a rubber bag holding three pints; D, a wash-bottle half filled with water. The wash-

bottle serves several important purposes: it indicates how fast the gas is flowing; it also calls attention if the valve of the cylinder be not closed tightly; arrests any dust that might be carried from the cylinder, or from the interior of the tubing or bag; and moistens the gas, thus preventing its absorbing moisture from the throat and air passages. At E is a mouthpiece attached by a rubber tube to the bottle; F, a rubber tube connecting rubber bag to B; and G, a rubber tube connecting the bag with the wash-bottle by means of a glass tube which extends nearly to the bottom of the bottle. In using the apparatus arrange the parts as shown in the Plate, being careful to place the leather washer properly at the outlet of the valve (B), and half fill the bottle (D) with water. Open the valve (B) very slowly and cautiously; the oxygen will then flow through the tube (F) to the gas bag (C). When the bag is filled the valve (B) may be closed and the apparatus is ready for use. If the valve (B) is open too much a portion of the gas may rush by the bag, and forcing its way through the water be lost; to correct this it is only necessary to partially close valve (B). In administering oxygen by the lungs the usual practice is to cause the patient to inhale very slowly from three to four gallons, say twice a day, taking it into the mouth through the glass tube, breathing at the same time through the nostrils. The gas should be retained in the lungs as long as possible, as more than this quantity may do harm. In severe cases of dyspnœa, asthma, croup, diphtheria or pneumonia much larger quantities may be required, as in a case of the latter disease, reported by Dr. Albert N. Blodgett (Boston Medical and Surgical Journal, November 20, 1890), which gives a record from his note book, as follows:

The patient was "in articulo mortis." Oxygen inhalations had been employed at intervals during the progress of the case, always with relief to the patient. He now directed that the administration of the gas be made continuous, not with any hope of curing, for he states that he was under the positive conviction that the patient was irrevocably doomed: the best result he looked for being simply relief to the sensation of suffocation. The gas was conveyed from the tank in which it was

supplied through a wash-bottle directly to the mouth of the patient, and a constant stream of gas was flowing through the tube all the time, so that with each of the rapid inspirations the patient was obtaining a constantly increased amount of oxygen. This was continued for 106 hours, the quantity of gas employed being not far from two hundred gallons in twenty-four hours. The patient having then progressed far enough toward convalescence to warrant it, the oxygen inhalations were discontinued. The patient was eventually restored to her previous condition of health. Commenting on the case, Dr. Blodgett said:

"I feel that in extreme dyspnœa or in threatened asphyxia we have in this agent the means of obtaining in many cases a distinct relief of the suffering, and a painless, if inevitable, death."

CHAPTER XII.

Mixed Anæsthetics.

The various mixtures of anæsthetics first received their impulse from the report of the Chloroform Committee of the Medical Chirurgical Society of London, who declared their superiority in point of safety. M. Perrin gives an account of the first death, known at that time to have taken place under a given mixture of ether and chloroform, and gives the credit to the chloroform as being improperly administered, and Snow says the patient died of hæmorrhage; but our reading of the case, carefully reported by Dr. R. Crockett,* leaves the decided impression that chloroform arrested the heart's action, inducing vomiting, and caused a stoppage of the respiration. The following is an abstract of the important facts in the case, and is interesting as the first death from the mixture: "A sprightly

* Am. Jour. Med. Sci., July, 1857, pp. 284–5.

little boy, five years of age, was brought to the doctor to have a fatty tumor removed from his back. The tumor, commencing at a point at its inferior termination, opposite the last rib, about two and a half inches to the right of the spinous processes, and extending obliquely upwards, crossing the spine seven inches, required two elliptical incisions, nine inches long, for its removal." The operation was commenced at 9.30 A.M., April 4th, and the dissection was rapidly executed, stopping to ligate a large artery that was early divided; the remaining arteries were compressed as they were divided. The tumor was quickly removed and a ligature applied to the last artery, being the sixth in number. While sponging the wound the boy began to vomit, and on examining the wrist he was found to be pulseless. Dr. K., who had charge of the anæsthetic and pulse, replied that "the pulse had never given way until he began to vomit." He ejected a small portion of the contents of the stomach. He was immediately placed in the "prone position," as recommended by Dr. Marshall Hall. The finger was introduced into the mouth to be certain that the tongue had not fallen back so as to obstruct the glottis, or the entrance of air into the windpipe, and the extremities were rubbed with aqua ammonia. The patient died three or four minutes from the commencement of the vomiting. "He lost probably four ounces of blood; certainly not exceeding six." There was no *post-mortem* examination.

The anæsthetic used was a mixture of washed ether, four parts, and one of chloroform, obtained from the late Frederick Brown, of Philadelphia, whose character is a sufficient guarantee that they were pure. Every preparation for the operation having been made, the administration of the anæsthetic was commenced by Dr. Crockett, observing all the precautions so fully recommended by Erichsen, p. 78, of his "Operative Surgery." As soon as anæsthesia was induced, the sponge was confided to Dr. Kincannon, who held his finger all the while on the patient's pulse. The doctor concludes, "I have lately employed this anæsthetic freely, formerly having used ether alone. *As yet I have not seen a case of death reported from ether*, or this mixture of it with chloroform, that I can now recollect.

Are there any such reported? I fear all the deaths from anæsthesia are not reported." Five deaths from the use of this mixture have been published.

The chief object of these anæsthetic mixtures is the avoidance of the danger from *shock*, or from the depressing influence upon the heart-action, which chloroform most certainly exerts, and which ether and alcohol prevent. The committee before referred to proposed the following mixtures:

		Parts.
A.	Alcohol,	1
	Chloroform,	2
	Ether,	3
B.	Chloroform,	1
	Ether,	4
C.	Chloroform,	1
	Ether,	2

Dr. Sansom's mixture* is equal parts by measure of chloroform and absolute alcohol. The introduction of alcohol, which plays an important part in the mixture, was, according to the doctor, due to Dr. Harley. The committee says it is by "the uniform blending of the ether and chloroform, when combined with alcohol, and probably the more equable escape of the constituents in vapor." The chloroform is the potent agent, and the others chiefly coadjutors, vehicles and diluents of the chloroform.

Dr. Sansom gives the following testimony as to the stimulating effects of alcohol in counteracting the depressing influence of chloroform: "In my own experiments I have found that alcohol has had the greatest effect in sustaining the heart-action during the influence of the chloroform. I can particularly recollect one instance, in which alcohol was administered in vapor to a frog, after it was impossible to cause death by any strength of chloroform vapor." In recommending this mixture before the Obstetrical Society of London, Dr. Sansom went one step farther, and stated that this mixture gives off a proportion of chloroform vapor in a given time almost exactly

* Chloroform: Its Action and Administration. By Arthur Sansom, M.B., London.

half of that which is given off by chloroform pure and simple. The result is not confirmed by any experiment of his published.

What are the objections to anæsthetic mixtures?

1. The length of time required for the production of complete anæsthesia. 2. The probability of entire sensibility not being abolished. 3. The unequal rate of evaporation or vaporization of the fluids.

There is not any doubt but that the process is slower and attended with more excitement by the mixed fluids than by chloroform alone. The second objection cannot be sustained. The third is the "element of danger." It was first advanced by Snow. He says: "When ether is combined with chloroform, the result is a combination of the undesirable qualities of both agents, without any compensating advantage," and the danger is because the operator, toward the end of the process, may be giving a pure chloroform when he thinks he is giving the weaker mixture of vapors. Dr. Ellis endeavored to prove this, and states: "Out of the six or seven minutes occupied by the evaporation of the half-drachm of fluid, the first was occupied chiefly by the ether, the next three by the chloroform with a little alcohol, and the last by the alcohol alone. In an inhaler, the patient would have breathed, for one-fifth of the time, chiefly the vapor of ether; for the next three-fifths, that of chloroform, with a little alcohol; and at last, only the vapor of a minute quantity of alcohol." These results are not stated as obtained by actual experiments, and they depend, first, upon the purity of the agents employed; second, upon the boiling-point, which has a great influence upon the results, for the more volatile the fluid, the greater will be the variation. We here give the boiling-point of the most important anæsthetics.

The temperature which is constant for the same substance, under the same atmospheric pressure, is called the *boiling-point.*

The following are the agents employed as anæsthetics in the form of vapor, the boiling-points being given for the mean pressure of 760 millimeters:

Protoxide of nitrogen,	88°
Carbonic acid,	78°
Chloride of ethyl v. pure ether,	11°
Ether,	35°
Chloroform,	63°
Alcohol,	78°
Oil of turpentine,	157°

A difference of pressure of 0.25 centimeter will cause a difference in the boiling of water one-tenth of a degree. The boiling-point is also influenced by dissolving in a fluid a substance more volatile than itself (as ether and chloroform); it increases the boiling-point in proportion to the amount dissolved. The temperature of the atmosphere has a powerful influence on these volatile agents, as it is a well-known chemical fact that the saturation of the air increases vastly with the increase of temperature, and the capacity of the air for aqueous vapor is doubled with each 27° of temperature, Fahrenheit. Sulphuric ether at 60° F. and thirty inches of the barometer expands two parts of the air into three, and forms, therefore, at that temperature and pressure, one-third of the air inhaled into the lungs of a patient. Under the same circumstances, chloroform expands fourteen parts of air into fifteen, and consequently the vapor of chloroform constitutes one-fifteenth part of the air inhaled.

The following experiments were made October 30, 1878, so as to determine the time required for each of the agents to evaporate on a given surface of tissue-paper, suspended in the air at a temperature of 70° F., one drop of each being carefully measured by the same dropping machine. The time was accurately kept by Dr. C. S. Turnbull, son of the writer, and the results served to confirm the rough experiments made before the Dental Convention at Washington, D. C., on October 10, 1878, and proved the facts stated in the author's first edition of this work. We have always found that when such a mixture was poured upon the inhaler, the most volatile spirit would rise first, then the next, and so on, leaving the least easily evaporated upon the inhaler. Another important fact was proven, and which was before referred to, that the alcohol employed in

the mixtures with chloroform in England, also the ethers made from such alcohols, are much inferior to those made in this country from grain, not from wood, potatoes or other agents. I regret to state this is no longer the case. These latter are slow in evaporation, and are mixtures themselves, containing a large amount of carbonaceous products.

The following are the results obtained, after numerous experiments, by the author, with as many of the agents employed in the various mixtures, and obtained from the reliable establishments of Powers & Weightman, Bullock & Crenshaw, Wyeth & Bro., and J. P. Remington :

	Min.	Sec.
Alcohol, absolute 95 (W. & Bro.),	1	24
Alcohol, common (W. & Bro.),	10	00
Chloroform (P. & W.),	00	24
Ether (Squibb's),	00	12
Ether, common, 0.750 (P. & W.),	00	24
Ether, Hydrobromic (R),	00	12
Methylic alcohol (B. & C.),	1	00
Potato spirit,* (B. & C.),	12	00

Temperature, 70 F.

Barometer, 30.08.

Time, 2 P.M.

Danger from the Water Produced from Ether.

Besides the danger from inhaling the ether pure and simple, there is another to be prevented ; that is, to get rid of the watery vapor from the mixture and also from the lungs of the patient, which collects on the sponge. If the napkin or inhaler is too close to the patient's mouth and nose, it will most effectually prevent air from reaching the lungs. How is this to be prevented? By squeezing out the sponge, napkin, lint, or if an inhaler is employed that cannot thus be treated, casting it aside, and taking a clean napkin, with as much starch in it as possible, so as to keep it in shape.

It has been well observed by Perrin : "We believe we shall render a veritable service if we popularize the idea that anæs-

* Passed through charcoal by W. & Bro.

thesia should be observed and studied at the hospital with as much care as every other subject of practical medicine." Sansom also says: "The administrator should be experienced. Several hospital committees have acted wisely in appointing a chloroformist, a measure which is not of less value to the operating surgeon than it is to the benefit of the patient. One who administers chloroform in any case should confine himself exclusively to the task he has undertaken, and should constantly mark the symptoms." What are the symptoms of danger? The failure of the pulse, irregularity of the respiration, and the blanched countenance, and, as beautifully expressed by an old writer in reference to successful administration of anæsthetics: "Proceed steadily but cautiously to the end in view. He who makes haste slowly, and with a boldness tempered by wisdom, carries his patient down into the dark valley which borders on death, drowns human agonies in the waters of Lethe, and triumphs in the crowning glory of his art."

The Inhalation of Chloroform and Ether a Cause of Aural Disease.

Cases of deafness are reported by Dr. Charles E. Hackey, of New York, as having followed the inhalation of chloroform for complete narcosis for surgical operations.

Dr. D. B. St. John Roosa, of New York, has also published that several cases of tinnitus aurium and loss of hearing have come under his observation, which were said to have been caused by the inhalation of ether for the purposes of anæsthesia. No such results have followed in our use of anæsthetics.

Brief Extract of Experiments with a Mixture of Ether and Bromide of Ethyl and Chloroform Performed by Drs. Reichert, Turnbull and Thomas, May 6, 1885.

Experiments were performed first upon a rabbit, then upon a dog. In the first instance a mixture of ether and bromide of ethyl (℥ij to Oj) was applied, and the animal prepared by inserting a tube, to which a pulse indicator was attached, into the

carotid artery, thereby showing the regular action of the heart. The trachea was opened and a tube applied.

The nasal branch of the fifth pair of nerves was irritated, and inhibition of the heart's action was immediately shown, and when repeated cessation was almost produced. The animal was allowed to recover, after which it was proposed to apply chloroform and repeat the test; but almost simultaneously with the application of the chloroform the heart's action ceased entirely, showing the dangerous character of that agent as an anæsthetic.

The post-mortem showed the lungs to be in a normal condition, as were also all the organs except the liver, which was badly tuberculous, a condition frequently found in the rabbit. A perceptible heart-motion continued for some time after death, but with insufficient force to propel the blood, the indicator remaining perfectly quiet.

In the second instance ether was applied to the dog with similar preparation as the rabbit, and with like result, after which he was injected with chloral, and a current of electricity was applied to the laryngeal branch of the pneumogastric nerve. The effect upon the heart was instantaneous to such an extent as to cause complete suspension of the pulsation. The result was the same when the current was applied to the pneumogastric, the continuance of which must have produced death.

Mixed Anæsthetics.

According to Dr. Wood it is probable that many of the difficulties which attend the use of ether can be overcome by putting in the inhaler, or the sponge, ethyl bromide and then ether, the patient passing insensibly from the bromide narcosis into that of the ether.

We prefer much better the plan to commence anæsthetization with nitrous oxide to be followed with ether, and which is employed by a few surgeons of this country. If the statistics which we give from St. Bartholomew's Hospital for this combination can be depended upon, in which 12,941 anæsthetizations were given, there being but *one death*, this is one of the most conclusive proofs to our mind of narcotic anæsthetic prop-

erties of nitrous oxide as not simply an asphyxiant that we have a record of.

A second death was reported in the *London Lancet*, 1896, of an individual under nitrous oxide and ether.

Dr. W. Atlee's Mixture.

It may again be inquired which is the best mixture to employ in ordinary surgical operations when it is absolutely necessary to employ such mixtures. The mixture C in midwifery. Mixture A, or, as it is familiarly known, A.-C.-E. or "ace-of-spades mixture," the most agreeable of all. In the operation for ovariotomy we prefer the C mixture, as also advised by the late Dr. Washington Atlee; the volumes of the two agents are so different that they ought to be mixed by weight, not by measure, else chloroform will be much in excess, as it is a little over twice the weight of ether. In employing alcohol it should be as near to absolute as possible, and free from any color, smell or taste. The ether should be almost anhydrous, pure, full strength, and well washed.

The late Dr. Atlee was of the opinion (which has been confirmed) that there is a chemical union of the ether and chloroform, for it has been found that, if this mixture was exposed to the light, a change took place which rendered the mixture not fit for the purposes of inhalation; it, therefore, should be kept from the light, and mixed just before being employed.

Perfectly dry chloroform decomposes but slowly, even in direct sunlight; but the presence of water, which always exists in alcohol and ether, and the action of light at the same time, causes chloroform to decompose into formic and hydrochloric acids. $CHCI_3 + 2H_2O = CH_2O_2 + 3HCL$.

We have had charge of the anæsthetic mixture (one part by measure of chloroform and two of washed ether) in an operation by the late Dr. Washington Atlee, during the successful removal of an ovarian tumor weighing forty pounds, and have also assisted him in three cases, in which others gave this same mixture, with good results, and with no apparent risk to the safety of the patient.

Dr. Atlee always administered the anæsthetic after the patient was upon the operating table, and one individual had charge of

and was responsible for it. In his three hundred ovariotomies, he informed me he had never lost a patient by the anæsthetic.

The mixture is given, in almost every instance, by means of the starched towel.

The following experiments were made to determine the action of ether and chloroform when mixed: When ether and chloroform are mixed there is an elevation of temperature, and the greatest heat is produced when the mixture is made in equivalent parts; that is, by weight, about nine and one-quarter parts of ether to thirteen and one-quarter parts of chloroform. As the chloroform is more than twice as heavy as ether, the volumes would be about one and four-tenths chloroform to two of ether. But little contraction in volume takes place, and it may be considered that molecular combination takes place between the chloroform and ether. The mixture begins to boil at 50° to 51° C., and may be separated into its constituents by fractional distillation; but when allowed to evaporate spontaneously, as when used as an anæsthetic, both liquids pass into vapor simultaneously.

Whatever mixture is employed, nothing will obviate the necessity of care in the administration, and, above all, do not give more of the agent than is absolutely necessary to keep the patient free from pain; not one drop more; for, like all patent medicines which we employ, an excessive dose is sure to kill, and unless we have before gauged the patient's powers, let caution be our guide in the administration of so powerful an anæsthetic. In our anxiety to see the various steps of an operation, we must not saturate the sponge or lean over the patient, and by accident suffocate him. It is, unfortunately, too much the practice to entrust the inhaling apparatus to some inexperienced hand, who, perhaps, never before administered an anæsthetic, and even in some hospitals to the youngest assistant surgeon or dresser.

An Abstract of the Reports of Recent Deaths from a Mixture of Ether and Chloroform.

The death of a lady had occurred in the practice of Dr. Eastham, a dentist of Boston, causing much excitement in professional circles. The death had taken place about noon,

but very few, except those particularly interested, were aware of it till the next day. The coroner, Dr. Ainsworth, who was called in directly after the accident, formed a jury of physicians and apothecaries, and ordered an autopsy. This was made the next morning by Dr. R. H. Fitz, pathologist to the Massachusetts General Hospital, and on the same day the jury met and, having viewed the body, adjourned until the 14th. The anæsthetic was either chloroform or a mixture of chloroform and ether. The latter proved to be the one used. The jury met again on the 14th, and, having heard a part of the evidence, readjourned till the evening of Wednesday the 19th. Instead of death resulting from ether, it was, as proved by the analysis, due to *chloroform*, and the coroner's jury presented the following verdict: "Death was caused by the inhalation of chloroform, administered in a mixture of chloroform and ether."

Dr. Henry Buren, of Chicago,* gives the following version of a death which took place in that city from the inhalation of a mixture of ether and chloroform:

"Mrs. B., aged 32, American, had suffered from fistulæ in ano for six months. On the 22d of November last I operated on her, finding at this time two artificial openings into the rectum, one on either side of the anus. Dr. A. Groesbeck administered the anæsthetic, which consisted of equal parts of sulphuric ether and chloroform. The operation was performed in a few seconds. The patient exhibited no alarming symptoms while under the influence of the anæsthetic, and revived in the usual time.

"On the morning of the 30th of November, eight days after the operation, I desired to make a thorough examination of the wounds and renew the dressing, and in this, as in some of the previous dressings, the patient insisted upon partial immunity from pain. To this end I commenced to administer upon a napkin two parts of sulphuric ether and one of chloroform. After a few inhalations the patient became violently intoxicated, and resisted, with great force, all efforts to quiet her, demanding, in the language of one in delirium, to be let alone.

* Chicago Medical Journal, February, 1878.

I immediately ceased to administer the anæsthetic, and with great effort prevented her from jumping from the bed. The face became at first turgid, the whole body convulsive, and in a few seconds the patient was dead.

"All of the means usually resorted to were employed to restore action of the vital functions; artificial respiration, elevating the lower extremities, dashing cold water in the face, drawing forward the tongue, spirits of ammonia applied to the nostrils, and finally a galvanic battery, which was conveniently at hand, but to no avail.

"I have to say, in justice to the record of this case, that the patient had for many years habitually partaken of opium. At the time of her unfortunate death she could take at each dose from two to three grains of morphia. During the time she was under my care one-half grain doses of morphia were prescribed at proper intervals, but she asserted that this quantity did not sufficiently support her, and through her nurse, and by stealth, she secured additional quantities from the neighboring drug stores, and took the same daily without my knowledge or consent.

"I am now of the opinion that the patient had taken an unusually large dose of morphia on the morning of her death, and that the combined influence of this overdose and the additional paralyzing effects of the anæsthetic caused cardiac syncope, and that this was the cause of death.

"A woman, aged 46, extremely fat, and of slow intelligence, although having complained of shortness of breath, was not known to be the subject of organic heart disease. She was to be operated upon for senile cataract. A mixture of chloroform and ether, in a modified Clover's apparatus, was being administered by the house surgeon. From the commencement of the administration respiration was noticed to be shallow, but there was struggling. The pulse was feeble, but not intermittent. There was some slight lividity of cheeks and forehead. Chloroform was at once removed and a few whiffs of pure ether administered as a stimulant. Other means for circulation were tried, but in vain; the patient died. At the post-mortem examination the heart was found flaccid and empty, the mitral

valve was contracted, the aortic valves were incompetent, kidneys fatty and granular.*

"In the spring of 1865, while stationed at the U. S. A. 'Summit' House General Hospital, Philadelphia, the staff were performing an amputation of the leg. At the suggestion of Surgeon Joseph Taylor, in charge, the A. C. E. mixture was used.† The anæsthetic was administered by Surgeon A. A. Leavitt, executive officer of the hospital. During the operation the patient's respiration failed. The condition became so alarming that the operation was temporarily discontinued, and all present turned their attention to restoring the patient. Artificial respiration, cutaneous excitation and inhalation of fumes of ammonia, fortunately, were successful. The operation was then finished, with the patient only partially unconscious. For many years I had not used this mixture, using either ether alone, or the mixture of ether two parts, chloroform one part, by weight; or, rarely, chloroform alone.

"During the past two years I have, on several occasions, used the A. C. E. mixture with gratifying results, being led to use it again by the favorable reports given by various authorities. During the summer of 1886 I was removing cancerous mammary and axillary glands, assisted by Drs. Martin and Chesney, of Cairo, West Virginia. To Dr. Chesney was intrusted the administration of the anæsthetic, which was the A. C. E. mixture. During the operation I had requested him to discontinue the anæsthetic, as the patient was sufficiently under the influence. This he did; he had his finger on the pulse, and devoted his entire attention to the patient's condition. The mammary gland had been removed, care being taken by Dr. Martin to prevent entrance of air into the veins. I noticed the extreme pallor of the patient's face, and simultaneously Dr. Chesney said the pulse had failed, so as to be inappreciable. I immediately placed a bottle of nitrite of amyl to her nostrils; respiration was good. Asking Dr. Martin to hold it there, I prepared a hypodermatic syringe with 20 m. of tr. digitalis, and injected it into the præcordial region. Dr. Martin meantime

* Med. Times and Gazette, August 18, 1876.

† W. H. Sharpe, M.D., Medical News, March 5, 1887, p. 257.

announced a slight recovery of pulse. I next administered several syringefuls (hypodermatically) of whiskey, and we had the pleasure of seeing the patient rally from this heart-failure, due, I think, to the depressing influence of the chloroform. It was carefully administered—with a sponge in a cone—*i.e.*, a towel stiffened with a sheet of paper in its folds; the sponge was held in its place in the apex by transfixing with long pins to prevent it falling down on the patient's face. The chloroform and ether were of reliable manufacture. It afterward developed that at this time the liver was involved in secondary cancerous inflammation, to which the patient succumbed a few weeks after recovery from the operation.

"A more recent case of *death* from a *mixture* of *ether* and *chloroform* is reported in the Philadelphia *Medical Times*, March 15, 1879, by I. A. Cleary, Assistant Surgeon U. S. A. Private H. D. B., Co. 19, U. S. Infantry, aged 33, large, robust; addicted to liquor. Injury of middle finger, right hand, resulting in gangrene; decided to amputate. A mixture of equal parts of ether and chloroform (*weight or measure not stated*). Two ounces of whiskey were given ten minutes prior to inhalation. The anæsthetic was administered on a piece of lint covered with a small towel held square. He personally administered the mixture, while the steward observed the pulse; air was freely admitted; he inhaled freely. About two drachms were first poured on the cloth, but with no apparent effect (*he, evidently, receiving nothing but ether*). Shortly after about the same quantity was poured on; he observed that 'he did not feel it.' After a time about the same quantity was again poured on. A further quantity was poured on the cloth (say, in all, ʒviij), when he began to laugh, followed by attempts to articulate, and made strong gesticulations with his arms. He now passed to a state of unconsciousness, when the pulse was not perceived. This was followed by relaxation and death. At once the anæsthetic was removed; cold water dashed in the face. He adds, 'Everything I ever heard of, saw or read, appropriate for such a case, was done, but to no effect.' He states as the cause of death paralysis of the heart (I think it was syncope from the chloroform)."

How Shall Nitrous Oxide and Ether be Administered?

Dr. Frederick W. Silk, of London, an anæsthetist of wide experience, has invented a useful apparatus for the production of anæsthesia by the combined method. In placing his invention before the profession, Dr. Silk himself comments on the striking similarity in the principle applied by him and that of Dr. Hewitt, who had pursued an independent line of work. The only difference between the apparatus of Dr. Silk and that of Dr. Hewitt is, that the valve arrangement between the face-piece and the ether-chamber in Dr. Hewitt's apparatus has been transferred by Dr. Silk to the face-piece itself, where it is controlled by the fingers of the hand holding the face-piece in position. Dr. Silk and Dr. Hewitt have both attained a method greatly superior to the usual one of an ether chamber suspended around the neck, and connected with a face-piece by means of the bag inclosing the tube. Dr. Silk, however, considers the new method still defective, because of the difficulty of administering nitrous oxide with a mere "whiff" of ether, as in dental work. The ether-chamber, when charged so that the indicator stands at 0, is so constructed that it is almost impossible, in warm weather especially, to prevent a very distinct and disagreeable odor of ether from pervading the face-piece at all times. Dr. Silk says that this apparently trifling objection becomes a serious one in the treatment of nervous and excitable patients.

Another difficulty is the total exclusion of air, which is so important a feature in the administration of nitrous oxide. Complicated mechanism—valves, stopcocks, chamber and pipe adjustments render this total exclusion difficult just so soon as the effects of wear and changes of temperature are manifest in the apparatus, and notably toward the close of the administration, when the bag is becoming empty, and the inspiratory effort is greater. Dr. Silk says that the gas reservoir should be brought as near the mouth as possible in all cases, and especially when it is narrow, with various divisions made by joints, valves, etc. There is always the possibility of leakage, and gas is moreover but feebly mobile.

In cases where nitrous oxide and ether are administered in succession Dr. Silk finds his apparatus often useful in abolishing the pulmonary spasm, and the struggling which is manifest in the later stages of narcosis ; but he expresses disappointment that these phases have not been entirely abolished, and that in some instances they have seemed to be intensified. This he attributes largely to the greater rapidity with which nitrous oxide narcosis is produced, as compared with that following ether, the former growing quite profound before the latter has reached the first stage. The consequent necessity for admitting air at that period retards the development of the final stages of ether narcosis, and prolongs or even intensifies the stage of struggling and excitement. In commenting on Dr. Hewitt's and his own apparatus, Dr. Silk says : "I am bound to confess, however, that it is a very distinct improvement on old methods, and that I still continue its use."—*Medical Register*, October, 298.

Mixtures of Nitrous Oxide, Ethers, Chloroform and Alcohol for Inhalation.

In our numerous experiments with the various anæsthetic agents we have always found it difficult to make any true chemical combination. Most of the vapors differ very much in density, and are given off at different temperatures, the vapor of chloroform being four times heavier than air ; and unless some means are employed to keep them in motion the denser vapor will gravitate to the bottom. Such is also the case with the liquid anæsthetics. They will, when shaken up, look, for the time, a perfect mixture ; but if allowed to stand, the heavier liquid, like chloroform, will sink to the bottom, and if the bottle is not well shaken each time when used the patient is apt, during the conclusion of a tedious operation, to receive the chloroform almost pure. The combination of nitrous oxide with ether had been carried out in England for many years, and we have given a description of Clover's apparatus, with his careful directions for use. Then we have the useful inhaling apparatus of Dr. Buxton, of London, with a reference to that of Drs. Silk and Hewitt ; also that of Drs. Codman and Shurt-

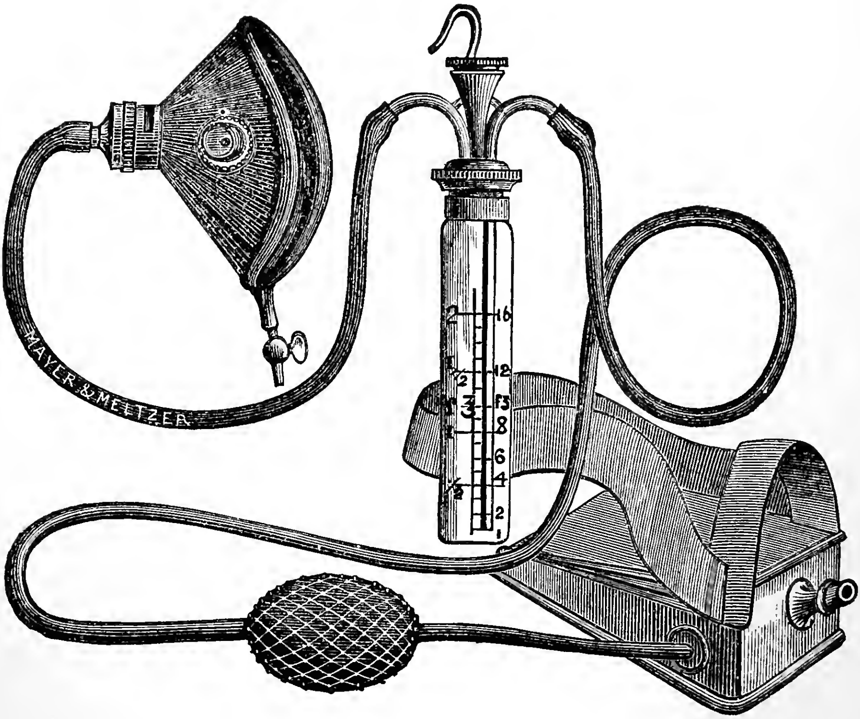
leff, of Boston. Another convenient attachment has been arranged by Dr. A. M. Long, by which the nitrous oxide gas is condensed into a liquid, and then mixed with ether, drop by drop, in a combining chamber. This apparatus has been employed, to a limited extent, at the Philadelphia Dental College, combining from twenty to thirty drops of ether to five gallons of the gas. It is well known that both nitrous oxide gas and ether are stimulants, and this combination should never be given to persons of full habit or flushed face, for fear of overaction of the vessels of the brain, producing convulsion or apoplexy. Mixtures of chloroform and nitrous oxide, or chloroform, alcohol and nitrous oxide, in the proportions of from five to six drops to five gallons of the gas, have been employed; but the fear is that unscrupulous persons would not limit themselves to this quantity, but would use a larger proportion, running the risk of destroying their patient.

We have already given our opinion of preparatory anæsthetic combinations of various agents to disguise the taste and smell of the anæsthetic, under bromide of ethyl, and would advise all persons administering anæsthetics to be sure of the agent they employ, so as to be able to counteract any dangerous element.

A mixture of nitrous oxide and ether vapor would explode on contact with flame or even a spark. It would not be spontaneously explosive, and would not be more dangerous than a mixture of ether vapor and air.

Junker's Inhaler.

PLATE 50.

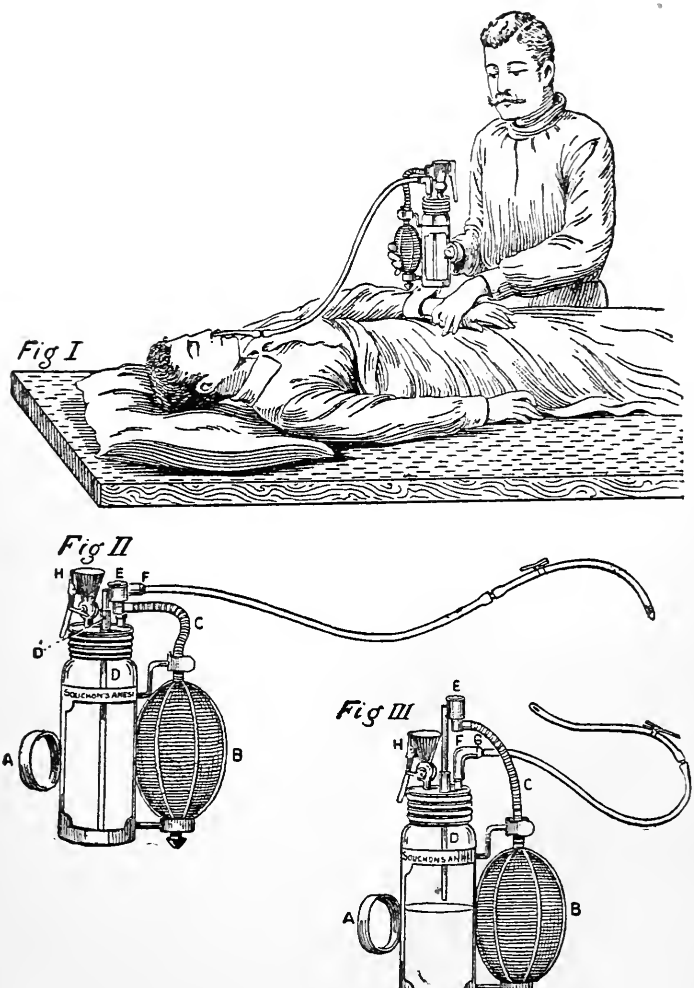


There should have been inserted at page 246 this plate of Junker's Inhaler for Chloroform, a full description of which will be found on that page.

Souchon's Improved Anæsthetizer.

[The cuts in this article were not received in time to be inserted in the paper on page 178. We therefore repeat a portion of the description which had to be omitted at that time.]

PLATE 51.



"DESCRIPTION OF APPARATUS.—The present improved apparatus is considered perfect in all particulars. It is composed of

a glass cylindrical receptacle, with a frame supporting a ring, A, for the thumb and a rubber bulb, B, so that it can be worked with one hand. From the bulb originates a rubber tube, C, wrapped with coiled wire to prevent it from bending; it ends in the inlet-tube, D; just at the point of junction, at E, is a ball-valve which prevents the liquid from entering the bulb when the pressure upon the latter is released. The inlet-tube extends through the liquid anæsthetic to the very bottom; its lower end is bevelled to prevent the orifice from being stopped by coming in contact with the bottom of the receptacle.

"This inlet-tube slides up and down through another shorter tube, D^1, so that it can be drawn well up above the level of the liquid anæsthetic, thereby diminishing the strength of the vapors injected through the outlet-tube into the pharynx. This feature makes the apparatus thus set an anæsthetizer of the first model.

"The receptacle is closed by a metallic lid that screws around its neck; a washer makes it air-tight.

"From this lid springs the metallic portion of the outlet-tube, F; it originates directly from the under surface of the lid; it is $\frac{1}{2}$ inch in diameter inside and $1\frac{1}{2}$ inches in height; after a *very sharp* curve of 90°, it terminates by an orifice of not less than $\frac{3}{16}$ inch."

PART FIFTH.

CHAPTER XIII.

Local Anæsthesia and Anæsthetics.

Electrical Osmosis and Cataphoresis.

Local anæsthesia has for its object to abolish the sensibility of the skin and other parts of the body. This is accomplished by certain local anæsthetics or substances which diminish the sensibility of the part by their contracting influence upon the peripheral or surface nerves or filaments of the deeper-seated nerves. The use of cold was one of the earliest and most efficient means of producing local anæsthesia, either in the form of snow or ice, with or without the chloride of sodium, or common salt, which was mixed with the broken ice and applied in a bag of linen, or now in a better form by the use of a rubber bag, which is arranged both for the convenience and comfort of the patient. The injection of ice-water is also used as a local anæsthetic. Then followed soon after their discovery, and to obviate the dangers of a general anæsthesia, the use of chloroform, ether, bromide of ethyl, rhigolene, carbon bisulphide, absolute alcohol, carbonic and carbolic acids, hydrochlorate of ammonia, also the bromide and sulphate of ammonia. The iron salts, particularly the sesquioxide, have an anæsthetic action without producing coagulation at the point of introduction. Acetate of lead is also an anæsthetic, and among organic substances, hydroquinine, resorcin, antipyrin, substances belonging to the digitalis group, and serpent venom, in small doses. Essential oils, such as oil of turpentine, hydrate of terebene, eucalyptol, oil of chamomile flowers, and a number of others, have a remarkable effect, according to Dr. Liebreich, who states that these substances act by destroying the nerve ends and by irritating the neighboring parts, causing what has been called "painful anæsthesia." Many of these agents act

by entering the circulation, and others by their direct effect upon the tissues. With regard to the cornea, there are two kinds of anæsthesia by subcutaneous injection of the dorsal region in rabbits and guinea pigs; for the eye, by allowing a few drops of the substance in solution to fall on the cornea. In preparing solutions, even of distilled waters, we must remember that the water acts as a caustic, and must be sterilized. The most important and valuable of all these local anæsthetics is cocaine, which causes no pain. It is, however, followed by contraction of the vessels.

Electricity as a Local Anæsthetic Alone or with Cocaine.

The pain felt during the extraction of a tooth is lessened by the employment of rapid respiration (Bonwell's method), violent muscular effort, or vibration. A still more powerful adjunct is *electricity* applied along the course of the nerves. The Faradaic, or interrupted galvanic current, was at one time employed in this city to produce a local anæsthesia. This employment of electricity has been revived by Dr. I. Corning, of New York, by first perforating the skin with needles with the instrument of "Baunschiedt," and then applying over the surface a sponge electrode saturated with a two per cent. solution of hydrochlorate of cocaine. This should be kept connected with the battery from three to four minutes, and be of sufficient intensity to cause a slight sensation of heat. It has been found safer, and that the method can be made more efficient, if the surface be blanched by the pressure of Esmarch's rubber bandage, as by this means strong solutions of cocaine can be employed with more safety.

Electrical Osmosis for the Treatment of Living Dentine.*

Electrical osmosis, electrical diffusion, anodal diffusion, and cataphoresis are terms used by different authorities to express nearly the same phenomena.

* Read before the New York Institute of Stomatology, November 26, 1895, by Henry W. Gillett, D. M.D. Reprint, Newport, February, 1896; also International Dental Journal, February, 1896.

The first three terms will be recognized as entirely synonymous, and need no defining to make them intelligible.

Electrical osmosis, the one chosen for my title, is probably the one having the widest acceptation among electricians.

Cataphoresis is a medical term which has come into use among electrotherapeutists, and is recognized by few electrical experts outside of those interested in medicine.

The definition of the term given by Dr. William J. Morton* seems to cover the ground fully. It is this :

"The movements of fluids, together with the substances they hold in solution, from the positive pole of electrodes conveying a continuous current in tissue towards the negative pole."

"When we consider this definition in connection with the human tooth, which generations of our profession have been striving to penetrate with some drug which should modify its sensitiveness, or with applications which should modify morbid conditions of the tooth-pulp, it becomes at once important, and, indeed, imperative that we make use of this principle, if we find it possible to do so. It is not necessary for me to mention before this audience the many advantages to accrue, for both patient and operator, from any feasible and harmless method of subduing the sensitiveness of the dentine of the human tooth.

"It is equally unnecessary for me to enumerate the many different means that have been tried to attain this end. It has not always happened that the means which have been tried and found helpful have proved harmless. The ill results from the use of arsenic and the strong mineral acids are examples of this fact. I have been amazed, within a year or two, to find a set of these so-called obtundents indorsed by members of our profession of recognized standing, which are of a most pernicious character. Upon applying to them simple tests within the reach of every intelligent operator, they reveal the fact that their efficiency is due to the most corrosive mineral acids."

Of course, every progressive operator has certain applications which he uses with success in some percentage of cases, but I

* Cataphoresis and solution of H_2O_2 for bleaching teeth, etc., Dental Cosmos, June, 1895. Note also the terms electric diffusion and electric medicamental diffusion, proposed by Dr. W. J. Morton.

think it is the universal experience to find that, in many of the cases where we need help most, none of these applications are of much assistance.

"For several years I have been taking a keen interest in a method of applying drugs to sensitive dentine, which seemed to promise a more universal usefulness than anything which we have before had at our command."*

Dr. Gillett sums up the results of his experiments as follows: Ten per cent. aqueous solution of cocaine applied on the positive electrode with a weak electric current for a few minutes will anæsthetize the skin. (Experiment No. 1.)

A similar cocaine solution applied for the same time without the current has no anæsthetic effect. (Experiment No. 2.)

The same electric current without the cocaine has no anæsthetic effect. (Experiment No. 3.)

Cocaine solutions of from fifteen to twenty-five per cent. applied in sensitive cavities for ten or twenty minutes do not modify their sensitiveness. (Experiments Nos. 4, 5, 6.)

The electric current alone applied to sensitive dentine, sodium-chloride solutions of varying strengths being added to insure good electrical connections, does not perceptibly modify the sensitiveness. (Experiments Nos. 8, 9, 11.)

Cocaine solutions and the electric current applied to sensitive dentine, together, *do* completely anæsthetize it; consequently the cocaine is the active agent. (Experiments Nos. 7, 10, 12.)

This treatment renders it possible to do for these nervous and hypersensitive organizations desirable operations, which, without some such means, are utterly impossible. It also enables the operator to perform much more satisfactory operations for sensitive children from twelve to sixteen years of age, and to do these operations (which would otherwise be entirely too formidable to contemplate) with no objection from the little patient and with no danger of exhaustion afterwards.

The effect of the cocaine in these applications does not seem to reach deeply into the dentine in most cases. By prolonging

* Dr. Gillett gives a full résumé of what had been done prior to his own experiments, which we have not space to give, but would recommend our readers to the original paper.

the application, however, the pulp itself may, in favorable cases, be anæsthetized, even through a layer of dentine.

It is quite often the case that a ten- or twelve-minute application will anæsthetize the dentine deeply enough to allow the greater portion or all of the cutting to be done painlessly, but for deep grooves it may be necessary to repeat the application. In cases where there is much sensitiveness, and consequently much time will be required to prepare the cavity at all, I find the time required for applying the cocaine is fully made up by the increased speed possible after the sensitiveness is under control.

"As to the time the cocaine effect persists, I find it difficult to get accurate knowledge. I am not always able to be certain whether renewed sensitiveness is due to penetration through the anæsthetized layer or to returning sensation. I had expected that the effect would be more lasting than cocaine effects in tissues, where the circulation is more rapid. I have, however, seen one or two cases where there had been a profound effect produced and where there was a return of the sensitiveness in fifteen or twenty minutes.

"As to the effect upon the pulp or the tooth, I have examined some of the teeth where the first applications were made, and I am unable to find any trace whatever of a permanent change in their condition.

"Some of my first work with cocaine and electrical osmosis was done in my own mouth. Stronger currents were used than I dare to apply in the mouths of my patients, and deep anæsthetic effects were obtained. No ill results have followed, and the tooth is normal in its sensitiveness after nearly a year's test. As to the applicability of the method, I find that it is almost universal. The exceptions are in the cases of the comparatively rare subjects who are not readily affected by cocaine, and the occasional case where the difficulties of insulating the tooth or cavity are too great.

"This latter class of cases will be much smaller in the hands of the expert operator, and this added necessity for the rubber dam will stimulate the operator's ingenuity in applying it in difficult cases. I very seldom find a case where I am unable to use the method with success, if I desire to do so.

"In my use of electrical osmosis I have found a single patient who is so sensitive to the current as to be only able to take a seven-volt current as a maximum. For her I readily anæsthetized a bicuspid so as to remove a portion of the pulp, but a large molar cavity required a long application, and was only a partial success.

"As to deep anæsthetic effects about the roots of teeth, I have not met with success in the limited trials I have made. I have received numerous queries as to the use of the method for extracting, but I see no probability of its replacing the present methods for that purpose. I have made one or two attempts to reach the nerve branches entering the tooth by applying the electrodes on opposite sides of the gums. The results were not encouraging, and in the case where my most determined efforts were made I produced a decidedly objectionable result in the breaking down of the gum tissue under the positive electrode. I have, however, obtained satisfactory results from cocaine cataphoresis on the sensitive gum about roots undergoing preparation from crowning.

"It would seem to me feasible to treat by electrical osmosis that very troublesome condition resulting from undue wear or erosion of the grinding surfaces of molar teeth, where the sensitiveness is almost a menace to health, by reason of its preventing proper mastication, and where it defies the action of the most violent caustics.

"For doing this work I have had made the instrument you see before you, technically an adapter or fractional volt selecter, the working of which I will explain.

"A milliampere metre is also almost essential. This selecter is intended for use with the Edison one hundred and ten volt continuous current. I have the Electro-Therapeutic Company at work devising a battery apparatus for use instead of the Edison current. I have not used batteries because I did not want to have the care of them, but when the incandescent current is not accessible, battery systems with a capacity of thirty or more volts may be successfully used with suitable modifying apparatus.

"First, let me enumerate the precautions necessary in using the one hundred and ten volt current."

Have the selecter connected according to the instructions provided with it.

An absolute safeguard, but one not necessary if connections are properly made, is to insulate the chair by placing linoleum or rubber under its feet, and also to see that gas pipes, water pipes, and any other wires are out of the reach or protected from contact.

"I always apply the rubber dam, as it is difficult, and often impossible, to prevent leakage of current through other tissues if this is not done.

"Any metal fillings which will be in contact with the wet cotton in the cavity or with the electrode must be covered. The current from a metallic surface into dentine is irritating and painful. I find Gilbert's temporary stopping a very useful material for this purpose. Wax will also do. In cases where I am working on an approximal cavity in one tooth, and a filling in the next tooth is too close to allow of its satisfactory insulation, I apply the rubber at first only over the tooth to be worked upon, thus insulating it completely; or, if the rubber is already in place, a second rubber may be applied over the tooth to be worked upon. The positive electrode should be of platinum, as most other metals are affected by the current and are liable to stain the tooth.

"These conditions being provided, see that your current is turned on. I always test this by touching the metal parts of the electrodes together, and watch the milliampère meter to observe the result."

"This selecter is so arranged that when the needle is at zero, and contact of electrodes is made as described, about one mili will be recorded. Getting this result insures the operator that all connections have been made and that the apparatus is ready. If, however, a larger quantity of current is indicated by the milliampère meter, it shows that the rheostat contact is not at the right place. This same proceeding would also serve to detect any break-down in the rheostat if it had occurred. Twenty seconds serve to assure the operator on these points if his apparatus is conveniently placed. I then wet the negative sponge electrode with water or dilute salt solution. I place in the

cavity a pellet of absorbent cotton saturated with a twenty to thirty per cent. cocaine solution. I prefer not to have this cotton extend outside of the cavity, and to keep the solution confined to the cavity as much as possible. This concentrates the current in the part I desire to affect.

"The negative wet sponge electrode I usually allow the patient to hold most of the time. It is preferable to be applied about the face or neck, as near the tooth as is convenient. Having placed this and allowed the patient to take it, I apply the positive electrode to the cotton in the cavity and begin slowly to increase the current by turning the large fibre knob of the rheostat head in the direction indicated by the needle which records voltage. The first consciousness of the current sometimes comes to the patient as the typical little 'kick' or 'kink' of the galvanic current, but it is a very small one with this selecter. More often the patient is only conscious of an indefinite, gradually increasing pressure, and if the current is pushed too rapidly this may increase to pain. It is therefore necessary to watch the patient carefully, and to pause in the turning-on process as soon as the change in the eye of the patient indicates that he is beginning to feel the current to an uncomfortable degree.

"After the first experience, if cautiously managed, a patient will usually give the operator all necessary indications for his guidance, and allow him to keep the current up to a point just short of pain.

"After one experience with it the sensation is readily borne, even by sensitive children of twelve or fourteen. In fact, they are often the most enthusiastic about its use.

"As the operator pauses at the point where the patient indicates that he is getting enough, or even turns back a little if there is too much current, it is well to assure the patient that any disagreeable sensation will subside promptly. It usually does this in from one-half minute to two minutes, and then the voltage may be increased slowly and gradually, with pauses long enough for any disagreeable sensation to disappear.

"Subjects differ very much in the amount of current they will bear without discomfort. It is usually found, however, that by

very gradual increase, and by taking more time to reach the maximum in these sensitive cases, a sufficient amount may be applied to any case to attain the result of anæsthetizing the dentine.

"It is my customary habit, as soon as I have opened into a sensitive cavity, to make an application lasting from eight to twelve minutes. If I have reason to expect difficulty with the case I make the application longer. If the first application is not sufficient for all I wish to do I repeat it later.

"I have some ten or twelve cases on record where twenty to thirty minutes have been needed to get sufficient effect. These were all cases where both patient and operator felt compensated for the time spent. Most of them were either extremely sensitive teeth or subjects who could bear but little current, and several of these cases would have been all but impossible without the aid of this method.

"On the other hand, I have numerous cases where ten or even eight minutes have been ample time for successful results.

"Having reached a voltage likely to be sufficient, I allow it to stand at that point till the end of the application.

"Fifteen to twenty volts will usually be attained in seven or eight minutes. In many cases, with small cavities and little sensitiveness to the current, twenty-five or thirty volts may be marked in the same time.

"The higher voltage works more rapidly.

"At the end of the application I usually break connection at the negative electrode, as there is less often any shock in so doing. If the subject is very sensitive to the current, I turn the voltage down low before breaking connection.

"Having concluded the application, I turn off the current in the selecter by means of the switch. This lever may also be used for concluding the application of current if you find no objectionable shock resulting.

"Then I test the cavity, and finding it all right proceed as usual, bearing in mind that the effect may not have gone as deeply as I wish to go with my instruments, so it is still necessary to watch for signs of returning sensitiveness.

"The expert electrical knowledge required for this process is

not such as to be a formidable obstacle to any skilful practitioner. The instructions provided will serve to arm him with sufficient knowledge for his first cases, and the other needed knowledge will come to him quickly as he goes on with his work.

"In connecting this selecter, it is only necessary to screw the plug provided into a lamp socket, and place the cords in the binding posts. Carry the wire from the positive binding post to the binding post of the milliampere metre, which is marked + (positive). Connect the cord attached to the positive platinum electrode to the other post of the milliampere metre, then lead the cord of the negative electrode from the unused post of the selecter.

"The electrodes may be readily detected by passing a current through a small piece of wet litmus paper. The positive pole will be found to redden the litmus, while the negative turns it blue."

The author reports a number of interesting and successful cases.

After a year's employment of electrical osmosis or cataphoresis by the method proposed and kindly explained in the presence of several well-known physicians and dental doctors by its author, Henry W. Gillett, D.M.D., it has been found by a good number of practitioners to be an efficient aid, particularly applicable to the cases of most extremely sensitive dentine.

Guaiacol-Cocaine Cataphoresis.

In a recent address before a New York dental society, Dr. James Morton described a method of producing local anæsthesia* more rapidly and more profoundly than by any means before known to him. This was by the use of guaiacol as a solvent for hydrochlorate of cocaine, and caused to penetrate tissue by the aid of the electric current, upon the principle of electro-physics cataphoresis which we have before referred to.

The writer states that electro-guaiacol cocaine anæsthesia re-

* The Dental Cosmos, January, 1896, No. 1, page 48.

quires two-thirds less time and two-thirds less current than aqueous solution of cocaine used by the cataphoric method. The formula for the mixture is:

℞ Guaiacol, ...	ʒj.	
Cocaine hydrochlorate, ...	gr.	M.

These quantities constitute a strong solution, containing from eight per cent. of cocaine to thirty-two per cent., and can, if desired (but we trust will not), be used without a great amount of care on the part of the operator.

Having already experimented with this new preparation on the skin and mucous membrane, he then employed it in producing anæsthesia of sensitive dentine, and he states with perfect success in cases reported.

He employed a new "fractional volt selecter" of the Electro-Therapeutic Co., which he states worked perfectly, controlling device of the current from the street mains. Also a new cataphoric electrode, by which the application is made to both sides of the gum.

Conclusions.*

"1. Electric medicamental diffusion ('cataphoresis') is not only a possible but a practical procedure; since,

"2. Sensitive dentine may, with the greatest ease, be so thoroughly anæsthetized that operations upon it and in it cause no pain.

"3. The dental pulp, even though not fully exposed, may be anæsthetized so that instruments may enter the pulp cavity without causing pain.

"4. By employing a properly constructed electrode, soft tissues like the gums may be completely anæsthetized.

"5. Soft tissues, like large areas (three inches by one and one-half inches by one-half inch deep) of the derma and subjacent tissues, may be completely anæsthetized for surgery."

This can be done without any current, by the Schleich method.

* Dental Cosmos, January, 1896.

"6. Guaiacol alone and other similar substances and derivatives in themselves non-conductors of electricity, by the addition of a very minute quantity of some innocent substance of an electrolytic nature, may be caused to penetrate tissue by the aid of electricity, and thus exhibit anæsthetic effects unobtainable without the aid of the added electrolyte.

"7. Guaiacol restrains the action of cocaine to local territory; increases the rate of its cataphoric penetration through the epidermis and other tissues; shows the rate of its absorption into the system; prevents consequent toxic effects; and adds its own anæsthetic qualities to those of cocaine."

After considerable use of guaiacol (see page on guaiacol) by the dental profession, it was found at times, either from impurities or its own nature being a creasote, a form of carbolic acid, to act as an irritant and caustic, so that it is no longer employed alone, but with fifteen per cent. of anhydrous hydrochlorate of cocaine, and termed guaiacocaine.*

Dr. E. C. Kirk, of Philadelphia, and W. J. Younger, of San Francisco, report excellent results from the use of guaiacocaine.

Dr. Kirk says that complete anæsthesia was produced in six and a half minutes, using a current varying from one-tenth to four and a half milliamperes.

At the Post-Graduate School and Hospital, New York, Dr. F. N. Wilson removed a large pigmented nævus from a patient. The nævus was three inches long by one and a half inches broad, and complete anæsthesia was obtained in five minutes, using the electric current as an adjunct. No pain was felt during the operation, nor whilst ten deep stitches were being inserted to close the wound. Regarding this operation, Dr. Morton says: "It is noteworthy in this case that the anæsthetic effects extended at least one-half an inch deep, and that there were no toxic effects of cocaine (a sixteen per cent. solution in guaiacol was used). The absence of toxic effects seems to me to be due to the fact that the guaiacol holds the cocaine in solution, thus localizing its action and preventing its diffusion into

* McKesson & Robbins, New York.

the circulation. This, if a fact, and it seems to be one, is of the highest importance, since the only objection which could be raised to the use of cocaine so extensively, and of such strength as described in the above instance, would be the danger of the absorption of a poisonous dose, especially in a highly vascular tissue, such as the nævus operated upon."

Prof. Michaux, in speaking of local anæsthesia, recommended the trial of the new combination of guaiacol and cocaine: "Guaiacol is one of the best solvents of cocaine, and being itself a slight local anæsthetic and non-conductor, it intensifies the action of the cocaine. It is also more profound in its action and is deeply penetrating. Its cataphoric application is also said to consume two-thirds less time and current than the simple cocaine solution. The sixteen per cent. solution appears to be the strength most commonly preferred.

"Besides producing an anæsthetic condition of the skin and mucous membrane, it has been used with perfect success for inducing anæsthesia of sensitive dentine."—*University College Bulletin.*

These powerful preparations of cocaine are not free from danger when used on soft tissues, or even on sensitive dentine where leakage through the rubber dam may occur, and a poisonous dose be swallowed which might prove very serious, especially in the case of a delicate person.

PART SIXTH.

LOCAL ANÆSTHETICS.

CHAPTER XIV.

Coca Plant, Leaves—Preparations, More Especially the Wine Made from the Leaves, also the Active Principle—Cocaine: Its Action as a Stimulant of the Nervous System and Retarder of Metamorphosis—Cocaine and its Salts, Solutions, Tests of Purity—Cocaine Inebriety and Habit, Treatment—Death from Cocaine.

Erythroxylon Coca; Folia Cocæ. The Leaves. Nat. Order: Erythroxylaceæ. Lamark. U. S. P. The coca is a small tree four to six feet high, indigenous to the mountains of Peru and Bolivia, and cultivated in both these countries on the eastern slope of the Andes, in damp, warm valleys. The leaves are chewed by the natives to satisfy hunger, to strengthen the weak, to stimulate the nerves and to remove depression or melancholy. The extract obtained by alcohol of 21° and 56° has all the gummy and resinous principles of the coca leaf, as well as the fatty, nitrogenous principles, the tannin, the chlorophyl and the alkaloid. It is this extract which represents best, and in exact proportion, the *constituent principles of coca.*

Like tea and coffee, coca is used in nervous headache, and as a substitute for opium in opium habit. A similar use has suggested itself in the treatment of alcoholism, spermatorrhœa, generative debility, granular pharyngitis and relaxation of the muscles of the larynx, pharynx and middle ear.

There is a wine of coca made from the fresh and dry leaves with sherry or claret wine.

PLATE 52—(Figs. 1-13).*

Wine of Coca, from Cocaine.

We have been disappointed in the results of the administration of the ordinary wine of coca in the market, and it has been suggested the preparing of this wine so that it will contain a fixed proportion of cocaine, and at the same time be free from the tannin, resin and other inert or deleterious substances present in the leaves.

To a good-bodied wine—claret—add two and a half grains of

*The entire illustration is that of branch with young foliage and flowers. No. 2, entire flower; between 2 and 3, petal; 4, flower with petals removed; 5, calyx and pistil; 6, vertical section ovary; 7 and 8, transverse sections ovary; 9 and 10, fruit; 11, transverse section of fruit; 12, section of stem with leaves removed; 13, apex of leaf

the hydrochlorate of cocaine to the pint, the dose being half a wine-glassful, which will contain about a twenty-fourth of a grain, repeated at each meal. We have found this wine of special value as a tonic to the vocal apparatus, or in cerebral hyperæmia, the result of excessive mental or physical disturbance. It has also been found useful in hysteria, and as a tonic and stimulant in weakened and exhausted nervous system.

Therapeutical Uses of Coca Leaves.

We have employed the coca and found it useful, first, in our own case, and also in that of several of our patients. The first effect of our experiments with the wine elixir and fluid extract of coca in full doses was a somewhat irregular muscular action or co-ordination, and if given in large doses walking becomes irregular. Soon after the moderate dose there comes a feeling of comfort, and as the effects pass off there is a slight irregularity of the rhythm of the heart. This is followed after a certain time, if taken at night, by a pleasant sleep. If taken through the day and not immediately before meals by a person with no desire for food, or if taken after meals, it passes off before the next regular meal and the appetite is not affected. The wine was the first preparation recommended to us, but after using that made in this city with sherry wine, we found it objectionable to certain of our patients, causing headache and dyspeptic symptoms; so that in Jefferson Medical College Hospital we resorted to a preparation of claret wine or the fluid extract in doses of sixty drops, three times a day. One week after, a patient with tinnitus reported that the noises were much less, throat less irritable, and it was possible to obtain a view of the vocal cords, which were found white, but still somewhat relaxed in the act of phonation. The only objection to its continued use in this form was the constipation. This constipation, it is stated by our patients, does not follow the use of the extract made with glycerine, or the lime-water infusion. Still the peculiar tannin which it contains is one of its important agents, and should not be omitted, as it unites with the active principle; therefore it is best to use the active preparation, for the constipation can be readily obviated by adding a mild laxative, like elixir of cascara.

In man the coca diminishes the appetite for food for some hours, and at the same time greatly increases the muscular strength and endurance. The celebrated traveler, "Tschudi," found, when coca leaves were taken in infusion, it conferred a singular immunity from suffering, and prevented the hæmorrhages which were apt to occur in the elevated passes of the Andes, some of which are 17,000 feet high. If used to excess, coca deranges the digestion and causes habitual constipation.

Cocaine and Its Salts.

In 1855 Gaedeke discovered in coca an alkaloid to which he gave the name erythroxyline; but this principle was first thoroughly studied by Dr. Albert Niemann, from whom it received the name cocaine, as an anæsthetic, but first used in the eye by Dr. Karl Koller, of Vienna.

The hydrated alkaloid cocaine is in light, white, spongy fragments, or in light amorphous powder, very much like magnesia. It is not perfectly white, but very nearly so. It is nearly insoluble in water, but very soluble in acids, giving solutions that are not quite colorless. When a very small particle is laid upon the tongue, and the tongue then held against the roof of the mouth, a moderately bitter taste is perceived. In a few seconds more the bitterness gives place to numbness and insensibility of the surfaces, as though scalded by hot liquid, except that there is no pain. This numbness increases for a few minutes and then diminishes slowly, and disappears in from ten to twenty minutes in proportion to the quantity applied. The hydrochlorate of cocaine is an almost white crystalline powder, though the fragments of crystals are so small that it appears to be an amorphous powder, even under a glass of low power. The powder when dry is loose and mobile, but when exposed to air becomes a little damp and clammy, although it does not appear to be deliquescent. It is soluble in all proportions in hot water, in alcohol, and in somewhat less than half its weight of water at ordinary temperatures. Its solutions are not always colorless, but appear to be nearly so when seen in small vials, even up to the strength of 20 per cent. Solutions of 50 or 60 per cent. strength are, however, of a greenish-yellow tint. The

solutions are neutral to test-paper. When tested with solution of chloride of barium they give, after a moment or two, the faintest cloud (limit of sulphates). With test solution of oxalate of ammonium the result is negative (absence of lime). When the salt is burnt on a platinum surface there is merely a trace of residue (limit of inorganic matter), and the spot moistened with water scarcely affects the color of neutral litmus paper (limit of inorganic alkalies).

According to Dr. Niemann, the discoverer of cocaine, the alkaloid, when heated in a tube, decomposes, with the evolution of a dense sublimate of benzoic acid. Wohler and Losson found, upon heating cocaine several hours in a sealed glass tube with concentrated hydrochloric acid, that the cocaine resolved itself into benzoic acid, methyl alcohol and ecognine.

Cocaine and Its Impurities.

The presence of hygrine and ecognine in the hydrochlorate of cocaine may be detected by treating the salt with cold concentrated sulphuric acid. If the salt is pure the result is a completely colorless solution. The impurities will stain the solution.

The Instability of Cocaine.

The great instability of cocaine is now well known, the simple contact of the free alkaloid with water being sufficient to decompose it. The hydrochlorate, which is much more stable, should be absolutely neutral; volatilized completely, forms a colorless or slightly turbid solution in water, gives a colorless solution with strong sulphuric acid, and should not reduce permanganate of potassium immediately.

Cocaine has the composition $C_{17}H_{21}NO_4$. It is slightly soluble in water, more so in alcohol and freely in ether. In addition to it coca leaves contain cocatannic acid, wax, and a pale, yellow, oily, volatile alkaloid, *hygrine*. *Ecognine*, which is obtained by the action of hydrochloric acid on cocaine, has the composition $C_9H_{15}NO_3$, and is insoluble in ether.

We had found it valuable in affections of the nose and ear, and had used it both before and after operation in a 5 to 10 per cent. solution, applied with a brush.

The test for cocaine is potassium permanganate, producing a permanganate salt, and when heated there is a distinct odor of bitter almonds.

Chloride of gold produces a distinct precipitate of small fern frond-shaped crystals arranged in stellate groups. A solution of iodide of potassium and picric acid produces precipitates of color, etc., which are peculiar to cocaine. The physiological tests are its anæsthetic influence on the eye, dilatation of the pupil and benumbing sensation on the tongue.

The test for pure cocaine (Stockman's), or pure hydrochlorate of pure cocaine, is that when heated with strong hydrochloric acid in a sealed glass tube, in the water bath, it splits up into its components without any change of color, except a very light yellow tint (from the HCI). When isatropylococine is so treated it splits up into ecognine and a brown, oily-looking body, which is decomposed isatropic acid. The anæsthetic properties of cocaine are destroyed by boiling.

Cocaine salts are now made synthetically on a large scale.

CHAPTER XV.

Experiments with Cocaine on Animals.

The Physiological Action of Cocaine Upon the Animal System, More Especially Upon Dogs.

Through the courtesy of Professor Reichert, of the University of Pennsylvania, the following experiments were performed in his laboratory, May 14, 1889 :

A dog, weighing 8 pounds, was injected with 1½ grains of Merck's cocaine. Pulse 172, temperature R. 38.9, being at the rate of 2 centigrammes per kilo. Soon after he became restless, moving his tongue in and out of his mouth, showing an extra secretion of saliva. Then followed jerking movements of the muscles, more especially of the neck and head, being unable to stand on his feet, as though intoxicated. The pupils became

dilated, balls very prominent and hard from increased intraocular pressure. In the course of ten minutes or more convulsions supervened. Temperature increased to 39.4°, pulse to 124. After 15 minutes there were both clonic and tonic convulsions. His bodily movements were in a circle, swaying his head from side to side. This motion of the head continued for several hours—even after the movement of the limbs, which had been lost, had been regained. A pinch was felt, showing no want of reflex excitability. When fully under the influence of the cocaine sight and hearing seemed unimpaired until convulsions set in. At times there was great difficulty in co-ordination, but there was no up and down motion of the head, and the convulsive motions were almost always rotary and to and fro.

SECOND EXPERIMENT.—Weight 16½ pounds, pulse 120, temperature 38.9°. Dose for his weight, 10 centigrammes. A much more timid animal than the first, and after 15 minutes became very restless, with his head at times between his feet, having a weaving motion, his mouth making a snapping movement. The grain and a half of cocaine which he received by injection did not appear to produce the desired intense physiological effects, so that one and a half grains extra was introduced over the spine. Now his brain became evidently very much affected, and his delirium overcame his timidity. When under great excitement he began by running around the laboratory, battering himself at intervals against anything that was in his way. Respiration increased, causing him to pant. Ears were thrown back, eyes protruding, balls hard, pupils dilated, but not to the same degree as the first animal.

It was early noticed that heat is increased in the human body by the use of cocaine. In 1887, Mosso, of Turin, demonstrated by experiment that this drug possessed a remarkable power over the bodily temperature, raising it independently of convulsions *or section of the spinal column*, and this is owing, according to Mosso, to direct changes in the tissue, or the action of cocaine on the heat centres supposed to exist in the spinal cord. These facts in regard to the section of the spinal cord have not been confirmed by Professor Reichert (see p. 53). In the experiments of Dr. Hare upon dogs only, one is noted as having

violent convulsions. A portion of cocaine employed by him varied from half a grain in a dog weighing nine pounds to three-quarters of a grain to a dog weighing seventeen pounds. In every instance the cocaine was injected into the jugular vein. Animals, like human beings, are affected differently.

The following are the most recent conclusions of Professor Reichert on the action of cocaine on animal heat functions: "There are comparatively few drugs known to therapeutists that are capable of causing a notable increase of bodily temperature, and even of these a large percentage is supposed to owe this activity largely or wholly to accompanying motor disturbances. It is at least a curious circumstance that all poisons which appreciably increase temperature are pronounced convulsants. Among the most decided of the physiological actions of cocaine is that of producing a rise of temperature which, even in moderate doses, may be quite remarkable. Von Anrep* states that the temperature of the skin was always decidedly increased from the first, while the rectal temperature at the same time remained unaltered, or was decreased from 0.5° to 1° C., the latter rising, however, during the convulsions, to a similar extent. Danini (quoted by Anrep) notes that a rise amounting to 1° C. occurs during, and is dependent upon, the convulsions. Mosso† always observed a rise, amounting to as much at times as 3.1° C., and, contrary to Danini, being independent of convulsions, since it occurred in animals rendered motionless by curare. Hare,‡ in ten experiments in which the drug was injected intravenously, records a rise varying from 2° to 7.5° F. (1.11° to 4.17° C.), the average being 4.14° F. (2.3° C.). Dose for dose the action is more powerful and prompt when intravenously injected than when hypodermatically."

In Reichert's studies, comprising about twenty experiments on dogs, a marked increase was always noted. "In all, Merck's hydrochlorate of cocaine was used and injected hypodermatically. The fatal dose in dogs is about 0.03 gram per kilo.

* Pfluger's Archiv., Bd. XXI. s. 68.

† Archiv. f. Exp. Path. u. Phar., Bd. XXIII. s. 153.

‡ University Medical Magazine, Vol. I., p. 358.

Doses of 0.0025 gram per kilo elicit fairly well-defined symptoms of cocaine poisoning, dilatation of the pupils, restlessness, salivation, increased frequency of respiration, more frequent and forcible pulse, increased temperature, etc. With such doses the temperature is increased about from 0.2° to 0.5° C. Doses of 0.01 gram per kilo cause a rise of from 1° to 2° C. Doses of 0.02 gram per kilo, a rise of from 2° to 4° C. The increase is, however, not always in proportion to the dose, relatively small doses sometimes causing a considerable rise, and *vice versa.* The potency of cocaine in this respect is altogether remarkable, and places the drug in the foremost rank of pyrogenic agents; indeed, so powerful is it at times that animals suffer from heat dyspnœa. Moreover, the action is one of notable permanency, the temperature, after large but sublethal doses, remaining above normal for six or eight hours or more.

"Following the rise of temperature and subsequent return to the normal, a fall ensues, which, even after moderate doses, lasts for some hours.

"The results of my experiments are not in accord with Von Anrep's statements above referred to, since in every instance a marked rise of temperature occurred, from the first simultaneously in the rectum and axilla (skin), the thermometers at both points of observation in our experiments being placed in position before giving the drugs, being allowed to settle, and not being removed during the entire time of observation. The alterations in temperature progressed *pari passu* in both cases. The rectal temperature rises more rapidly than that of the skin, this being due, to a large extent, if not wholly, to the quicker reaction of the thermometer in the former position. The thermometers used, when placed in the rectum, settle in from three to five minutes, but from ten to fifteen minutes are required in the axilla, although the thermometers were identical in make and sensitiveness." We cannot give the full details of Dr. Reichert's experiments, but he showed that a rise in temperature does not occur after section of the spinal cord.

We have shown by the above experiments on dogs the action of cocaine.

On the Action of Cocaine on the Eye.

When introduced into the eye, it causes local anæsthesia, with dilatation of the pupil, paralysis of accommodation, slight lachrymation, and enlargement of the palpebral fissure.

When injected into the back of the orbit, it causes protrusion of the eyeball. Its effects appear to be due to stimulation of the peripheral ends of the sympathetic. Subcutaneous injections also produce local anæsthesia at the point of application, so that subsequent irritation at that spot produces no sensation in man and no reflex action in animals. When taken internally, it appears to have in small doses a stimulating, and in large doses a paralyzing action on the nerve centres. It affects first the cerebral hemisphere, next the medulla, and afterwards the spinal cord.

The writer has performed numerous experiments on himself and others to determine the action of the alkaloid cocaine and its chief salt, the hydrochlorate.

In moderate doses of the hydrochlorate it can be administered in from one-fifth to even one-quarter of a grain every hour, until the patient is relieved, or the peculiar constitutional symptoms show themselves, these doses acting as a stimulant on the peripheral ends of the sympathetic. In larger doses it has an action on the nerve centres, affecting first the cerebrum, next the medulla, afterwards the spinal cord. If employed in still larger doses there is intense exhilaration, or intoxication, more or less loss of consciousness, followed by palpitation and even death, although this is rare. I have seen no deaths from cocaine for the last six years in Philadelphia.

Fatal Dose of Hydrochlorate of Cocaine.

Peculiar effects: A nervous thrill or tingling sensation, increase of pulse, dryness of the tongue, relief of pain or gastric disturbance, sensation of fulness in the head or heat of the face, at times producing wakefulness, followed by frontal headache; in other cases there is dilatation of the pupil, with a tendency to sleep, the patient awaking in his ordinary condition of mind. If larger doses are required, the symptoms are

similar in character, only increased in intensity, great mental excitement, increased irregularity in rhythm or force of the heart, insomnia, or being unable to sleep, and invariably headache the following morning.

The fatal dose is usually from six to ten grains, but from idiosyncrasy or peculiarity of constitution a much smaller dose may prove fatal. Dr. Hammond, of New York, took very much larger doses. Before the last injection the pulsations of the heart were 140 to the minute, and characteristically irregular. He found his mind passing beyond his control, and he was becoming an irresponsible agent. He lost all consciousness half an hour after administering the last dose, remaining so until nine o'clock next morning, when he awoke with an intense headache with a great deal of cardiac and respiratory disturbance.

No marked influence appeared to be exercised upon his spinal cord or upon the ganglia at the base of the brain.

There were no disturbances of sensibility (no anæsthesia, no hyperæsthesia), and no interference with mobility except that some of the muscles, especially those of the face, were subjected to slight twitchings.

In regard to sight and hearing he noticed that both were affected; but that while the sharpness of vision was decidedly lessened, the hearing was increased in acuteness. At no time were there any hallucinations.

The exciting action of cocaine on the brain is extremely prominent among its physiological peculiarities—much more so than its anæsthetic influence.

1. The first noticeable effect on the lower animals is restlessness, gradually increasing to more or less intense excitement.

2. In animals the cerebellum is more or less affected.

3. Chloral is certainly antagonistic—so with chloroform, also ether—during anæsthetic stage, but not during its primary stage of excitement.

4. There is some evidence to indicate that the semi-circular canals are affected, as shown by the vertiginous movements.

5. In poisonous doses the convulsions seem to be both of cerebral and spinal origin, but chiefly cerebral.

6. The motor or sensory nerves do not seem to be affected until late in the poisoning.

7. The action on circulation is complex; pneumogastric nerves primarily stimulated, secondarily depressed. Blood pressure similarly affected. Therapeutic doses probably act as circulatory stimulant.

8. The pupils in all of the experiments were dilated and intra-ocular pressure increased. We have never noticed any injurious effects on animals in any way after using non-lethal doses. They naturally suffer some after-depression because of the intense mental and muscular excitement during the action of the poison.

9. Bodily temperature is increased.

10. Tissue metamorphosis, as is indicated by Dr. Reichert's experiments, is probably increased.

11. The fatal dose for animals is about 0.03 grammes per kilo of body weight. The fatal dose for man varies within very wide limits.

12. It is claimed that it at times interferes with the healing of the wound after operations, and to be less efficient on other membranes than the conjunctiva.

CHAPTER XVI.

Cocaine Inebriation and Habit—Treatment—Deaths from Cocaine—Morbid Changes in Poisoning by Cocaine.

In the cases under Dr. Crother's care a correct history was obtained; in the five cases who sought advice by person and letter their own personal statements were the chief sources of information. In two cases statements were confirmed by others, and where such statements corresponded with the facts in other cases, they were accepted as probably true. The following are some of the facts which appeared from the history of these cases:

Alcohol, opium, chloral, bromides and other narcotics had been used more or less to excess in all these cases before cocaine was taken. In four of these cases coca had been used for months before cocaine was tried. Hence they were all literally drug maniacs, or inebriates, whose special symptom of disease is a morbid impulse for narcotic drugs, which will bring rest and relief to the organism. He is also persuaded to believe that cocaine inebriety, or coca mania, will never become prominent, and will be confined to a class of neurotics who, by the use of other drugs, have prepared the soil for this new drug-mania. It will never take the place of alcohol or opium in common use. Its action is too uncertain and transient. The present novelty and glamour about its effects will die away when its real value is ascertained. The element of contagion in these cases presents a curious psychological phase; thus some extravagant newspaper statement of the terrible effects of this drug will rouse curiosity to test it, or the printed history of a case appearing as daily news draws the attention of neurotics, and it is safe to say that a large per cent. not only purchase, but test this drug on themselves. Cocaine should not be used as a substitute in breaking away from the use of other narcotics. It should not be used in large or long-continued doses. It cannot be used indiscriminately. However valuable it may be, there is a certain limit to its power and practical use.

The treatment of cocaine inebriety is the same as that of alcohol or opium cases. *Forced abstinence from the drug, rest and building up the system are the general methods pursued.* More profound degeneration and debility exist than in other forms of inebriety, requiring a longer time for successful treatment. Clouston (*Edinb. Med. Jour.*, 1891) advises stopping the drug, careful watching, nursing, the use of every sort of food that will keep up the strength, and of the bromide of ammonium, brandy or wine, tea and coffee, and possibly a hypnotic, like paraldehyde or sulphonal, for at least two or three nights.

States of mania and melancholy often continue for some time after the use of the drug is given up, and disappear very slowly. It is for these states that special surroundings and

care are essential. The prognosis is always uncertain. The craving for drugs that their effects may be broken up and restoration follow; but such cases generally are unable to bear much exposure, and not unfrequently relapse on the slightest temptation.

On making inquiry of Dr. Osler, now of Baltimore, one of the attending physicians of the largest hospital in Philadelphia, as to how many cases he had ever seen of cocaine habit, he stated but one or two, and of opium or morphia habit, during his term of service of four months, there were but four cases. In what dose did he give cocaine? As a rule, one-quarter of a grain was the usual dose, and the strength of the solution for hypodermic application was two per cent. If this rule is followed, we think that it is as safe as morphine, atropine and agents of a like character.

Treatment of Nervous Symptoms from Cocaine.

Should nervous symptoms occur, such as temporary deafness, blindness, loss of taste or smell, place the patient on a lounge or sofa, open the windows and admit plenty of pure air, then employ from five to ten drops of the nitrate of amyl in capsules, broken on a handkerchief, to be inhaled by the nostrils. Should the patient become covered with cold perspiration, livid in color, apply dry friction to the skin, with twenty drops of aromatic spirits of ammonia, in water, repeated at intervals. Should the patient suffer from gastric cramps, give a teaspoonful of compound spirits of lavender, or, if not relieved, brandy. Use morphine, hypodermically, one-eighth of a grain. If the pulse be irregular or intermittent, with shallow, gasping, irregular, convulsive or suspended breathing, artificial respiration should be resorted to, with hypodermic injections of ether or chloroform, and even the galvanic battery, to prevent a fatal result.

In cases of poisoning, the nitrate of amyl is considered the best antidote. Claude Bernard has demonstrated by his experiments that cocaine, in its action on the cerebral circulation, was exactly the antagonist of nitrate of amyl. Under the effects of amyl, the cerebral arteries contract, anæmia of the brain de-

velops, the arterial pressure is increased and the face looks pale. Cocaine causes a dilatation of the vessels of the heart, hyperæmia, with diminished arterial pressure, sets in, in the encephalon, and the face appears flushed and in a general state of venous congestion. Cocaine is antagonistic in its action to ether and chloroform. The convulsive seizures induced by the action of poisonous doses of cocaine can be at once allayed by the inhalation of either of these agents. In cases of cocaine poisoning in man, we therefore recommend that ether or chloroform should be administered to allay the first and severer symptoms, chloral being afterward given in small doses to keep up the effect.

We were highly delighted to find, from a pamphlet of Prof. Viau,* that he had been able to modify the hydrochlorate of cocaine in solution with pure phenol, gr. ij., to cocaine, gr. iv., to 100 grs. distilled water, so as to prevent, in 87 cases, any unpleasant results from its use in the extraction of teeth. This solution was prepared as directed by the Paris dental surgeon :

℞ Crystallized phenic acid, ... gr. j.
Cocaine, pure, ... grs. ij.
Distilled water, ... grs. 100. M.
Sol. and filter. Make each time that it is employed.

And before a class of about 200 students the mixture was injected into the jaw in a case of diseased antrum in a young lady. She was then operated upon by Dr. Garretson, who removed the diseased bone with the dental engine. She bore the operation with great equanimity, and with so little pain as to be unnoticed by the students; and when asked, at the completion of the operation, she stated that she experienced some slight pain. The case was an interesting one in its freedom from excitement and haste, and the quiet way in which she would rise, expectorate the blood and be cleansed from the horrible disfigurement, avoiding the great risk produced by profound anæsthesia, which is so nigh unto death, required in such an important operation.

* Monograph, by Prof. George Viau, Paris, 1892.

Schleich's Infiltration Method of Local Anæsthesia by Cocaine.*

Dr. H. V. Würdemann was the first to use the method of "Schleich" in the United States, and gives the following important testimony in favor of this method: "He has personally done half a hundred operations upon the eyelids, etc., by this form of anæsthesia, as well as various operations upon other parts of the body while prosecuting his original investigations. He also assisted at a number of operations, as ovarian tumors, amputations, hernias—to all the minor operations."

Schleich, in an extensive use of his method for at least one year, makes the following statement, that local anæsthesia with *cocaine* can be employed successfully in ninety per cent. in all operations. Another advantage he claims is the rapidity of its application and the short time in the preparation of the patient, and the safety, if his rules are carried out. Again, the after-effects, as vomiting and depression, are much more rare. As we have already stated, he employs various strengths of the solution. He seems to prefer the medium strength of solution, which has but one part, with two parts of sterilized chloride of sodium to one thousand. If the skin is very sensitive to the puncture of the needle, the part is sprayed by ethyl chloride; or, if it is in a mucous surface, by the five per cent. solution of carbolic acid. A free application of glycerine over all surrounding parts is also highly recommended.

It must be particularly remarked that the infiltration on one spot lasts from fifteen to twenty minutes, and should it be found necessary to return to such a spot at the expiration of this time, a fresh infiltration would be necessary. In this way we may operate for hours on the same spot.

It must also be remembered, that after the period above mentioned, the parts of skin which have been held back during the operation, must be anæsthetized over again, and care should be taken to make the wheals large enough to allow space for the thread and knots, one method being to produce one on

* The Infiltration Method of Anæsthesia. Reprint Am. Med. Asso., November 16, 1895.

each side of the separated cuticle, and draw the needle and thread through the centre of these.

Inflamed Parts.

There is a great difference of sensibility in the anæsthetizing of a normal part, or of a highly sensitive one, such as inflamed parts by abscess, tumors, etc. In these cases it is absolutely necessary to start the anæsthesia in the healthy parts. Begin the infiltration far back from the seat of inflammation, and insert the needle through the first-formed wheal gradually, while pressing steadily on the piston, deep into the part toward the seat, emptying the syringe all outside of the inflamed zone.

In this way the infiltration is carried on from the four opposite points at first, and then only gradually the upper cuticle is treated, and this also beginning first in the healthy region.

In this way wheal after wheal is formed until the whole of the inflamed part is saturated, which can be readily observed by the disappearance of the red inflamed color and its substitution by the white zone of the infiltration.

The best action of this form of anæsthesia has been found on parts like the fingers or toes or penis. The return circulation can be interrupted by circular constriction, and the entire quantity can be retained.

Corning has used hard rings pressed upon flat skin-areas in order to similarly interrupt the circulation of the fluids that tend to carry away the anæsthetizing substance. Under this practice there are three zones of sensory nerve-activity—a zone of complete anæsthesia corresponding to the area in which the cocaine is in sufficient concentration to completely overcome the sensibility of the nerve-endings and filaments, a zone in which sensation is partially inhibited, and an area in which the anæsthesia gradually fades away.

It was easily seen that if by osmosis or by the mechanical movement of fluids the cocaine was brought into contact with all the nerve-structures in approximately one degree of concentration, and if this contraction were exactly that required to inhibit nerve-action, the desired result would be accomplished with a minimum quantity of the drug.

Lieberich and Würdemann have shown, however, that the injection of simple water into the tissues in such a way as to produce an artificial œdema will induce, with some discomfort, a transitory anæsthesia. C. L. Schleich found that by combining a small quantity of cocaine with a weak salt-solution, the discomfort was removed and the anæsthesia prolonged; and it only remained to add a little morphine to the solution to prolong the beneficent action sufficiently to give opportunity for the performance of surgical operations. Some surgeons add a minute quantity of atropine. Complete anæsthesia depends, in this method, upon the artificial ischæmia established, and upon the high pressure to which the tissues are subjected; also upon the lowered temperature brought about by the introduction of the cool water; and finally upon the direct action of the anæsthetizing drugs. Leaving aside alleged personal disinclination on the part of European clinicians to adopt the method of Dr. Schleich, it seems to me that the failure of the infiltration-method up to the present time to become popular, depends upon the fact that a special technic is required. This technic is, however, so simple and easy that American physicians, I am sure, need only read an account of it to understand and practice it. And, as local anæsthesia can be induced by it in a few moments for the opening of abscesses, furuncles, or carbuncles, for the removal of a prepuce, or for the amputation of fingers, or even of the forearm, with the use of a solution of *one part of cocaine in a thousand of water*, every intelligent worker must grant its advantages and apply it in practice. The hypodermic syringe which he employs is larger and the needles longer, and of various lengths, being straight and curved. It has been suggested to have an asbestos packing. These needles are always kept ready for use in an antiseptic solution of carbolic acid. The parts before operation should be shaved, and all hair removed, except in the eyelashes or eyebrows, and should be well washed with Castile soap and hot water, followed by alcohol, and last—but not least in importance—a solution of one to five thousand of bichloride of mercury.

The following formulas are advocated by Schleich:*

* Translation by Dr. H. V. Würdemann. Pamphlet, p. 3.

℞	Cocaine mur.,	.20
	Morph. mur.,	.025
	Natr. chlor.,	.20
	Aqu. dest. ad.,	100.

M. Sterilisat. adde. sol. ac. carbol. 5 per cent. gtt. ij.

S. Solution No. 1, strong. For operating upon highly inflamed or hyperesthetic areas.

℞	Cocaine mur.,	.10
	Morph. mur.,	.025
	Natr. chlor.,	.20
	Aqu. dest. ad.,	100.

M. Sterilisat. adde. ac. carbol. 5 per cent. gtt. ij.

S. Solution No. 2, medium. For most operations.

℞	Cocaine mur.,	.01
	Morph. mur.,	.005
	Natr. chlor.,	.20
	Aqu. dest. ad.,	100.

M. Sterilisat. adde. sol. ac. carbol. 5 per cent. gtt. ij.

S. Solution No. 3, weak. For superficial operations upon nearly normal tissues.

All are to be kept strictly sterile; glass stoppers or scorched cotton, such as are used in bacteriologic experiments for the bottles; small quantities to be poured out in smaller vessels for each operation. Just before operation the solution should be cooled by laying the bottle containing it on ice. The common form of hypodermatic syringe with the finest of needles is all that is usually needed. Dr. Chas. Denison, of Denver, Colo., has given us an aseptible syringe of larger capacity, with piston packing of asbestos, which is particularly applicable for aseptic injection. The syringe is kept in good order by being frequently soaked in a five per cent. carbolic solution and the needle sterilized after each operation.

The discovery of these truths, so valuable for the question of local anæsthesia, is due simply to a slight change of method—the application of the solution within and not under the skin. The anæsthesia is caused by the replacement of the normal fluids of the tissues by a fluid of less specific gravity (the water),

which causes anæmia, compression and cooling, producing thereby a temporary paralysis of the nerve filaments. The pain of the infiltration of indifferent solutions is abolished by the minute doses of narcotic drugs (morph., cocaine, carb. ac.).

"It is perhaps well to here go into the technique of the production of local anæsthesia by this method. The field of operation is made aseptic in the usual manner. Having the required formula, the solution aseptic and cold, we fill the sterilized hypodermic syringe, pinching the skin slightly between the thumb and forefinger of the left hand; the needle is then passed obliquely under the epidermis to the papillæ, intra-

PLATE 53.

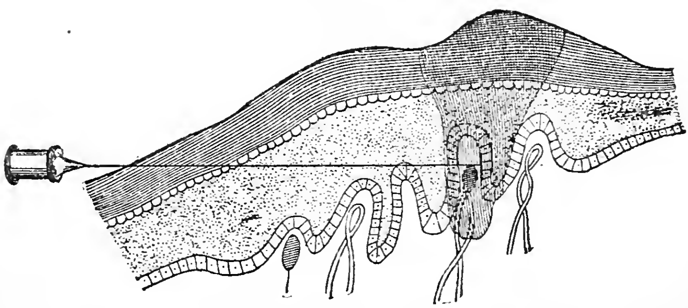
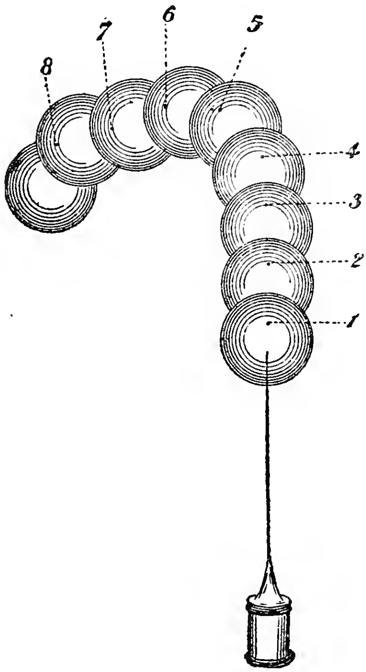


Diagram of a section of the skin, showing formation of the first wheal.

cutaneously, until the lumen is fully inserted. A few drops are then injected, thereby producing a white elevated wheal, the infiltration extending throughout the whole thickness of the skin. (See Plate 53.) There is immediate and complete anæsthesia throughout the extent of the infiltration, which lasts from ten to twenty minutes, according to the density of the tissue so œdematized. The needle is then re-inserted at the periphery of the wheal, and the area infiltrated to the required extent and depth. No tissue offers any deviation from the dictum; every structure is made anæsthetic that can be artificially œdematized: this holds good for skin, mucous and synovial membrane, periosteum, fascia, muscle, lymph glands, nerves, viscera, and even bone."

Anæsthesia exists only within the area infiltrated by the solution, and outside of that normal sensation remains. In operations on or through the skin and mucous membranes, the first wheal is increased to the size of a dime by increased pressure on the piston; the needle is moved and re-inserted at the periphery of the wheal, but still within it, and a new wheal

PLATE 54.



Formation of the cutaneous wheals.

raised. In this way the line of incision is marked out to any desired length or breadth. (See Plate 54.) In general surgical operations we would then infiltrate the underlying tissues by slowly pushing in the needle and injecting a few drops at a time until the deeper tissue is œdematized.

By cooling the spot selected for the formation of the first wheal by ether or rhigolene spray, or, on mucous membranes, by touching the spot with a strong solution of carbolic acid or

applying cocaine, the first injection may be made, if so desired, without even feeling the prick of the needle. This is seldom necessary, as a very fine needle may be inserted without pain even in very tender tissues, such as the eyelids. The succeeding injections may now be made without causing sensation. There is no sensation to the infiltration proper.

Where the tissues are inflamed, the sensibility is pathologically increased. Here it is indispensable that the infiltration be begun in sound tissue and carried over into the part to be operated upon. The dilated blood and lymph channels of the inflamed skin allow us to anæsthetize quite a large spot from one puncture.

The injection should be done slowly at first, and when the infiltration is only felt by its tension we may rapidly flood the part to the required extent. Under no circumstances must the fluid be primarily injected into an abscess, an exudation or a pathologic focus. The only result is increased tension and pain. We must not lose sight of the cardinal fact that the anæsthesia exists only within the area infiltrated by these solutions, and that outside of that there is normal sensation. The method rests principally on the production of a complete artificial œdema of the tissues. Wherever we wish to operate with exact anæsthesia, the field of operation must be tensely filled with the solution, so that it exudes from the cut surface.

The following important caution Dr. Würdemann has published as late as February, 1896, and has kindly placed it at our disposal:

Notes on the Danger of Sepsis in Endermatic Injection (Infiltration Anæsthesia).*

"The growing popularity of infiltration anæsthesia since its discovery, in 1891, by Schleich, of Berlin, and subsequent introduction into Germany and America one and a half years ago, leads me to sound a note of warning regarding its indiscriminate use without proper care as to the technique. The only substantial objection to this form of local anæsthesia that has been

* See editorial in Medical News, February, 1896.

heretofore raised is that of the possibility of infection from septic fluids, unclean hands or instruments.

"There are certainly many physicians who either do not clean their hypodermatic syringes or simply wipe them off, and then go to the next patient. It is not customary to make special preparation of the skin, or of the hypodermatic needle, for ordinary hypodermatic injection. Even the fluid used in which to dissolve the morphine, etc., tablet is not always drawn from an aseptic source. The small amount of serum which clings to the needle on withdrawal is certainly a culture medium for the streptococcus.

"It is remarkable that we see or hear but little of hypodermatic abscess, which, despite septic injection, must be an uncommon occurrence. We can only ascribe this to the fact that in the hypodermatic injection the fluid is deposited in a comparatively compact depot under the skin, and does not come intimately in contact with the cells of the tissue, and thus permits of rapid phagocytosis, as the blood is not driven out of the surrounding tissue and the fluid is rapidly absorbed. Quite different is endermatic injection, for when fluid is slowly infiltrated into the tissues it distends the meshes, replacing the fluids and the blood entirely for a length of time (10 to 20 minutes). The infiltrating fluid is brought intimately into relation with the cellular elements, and phagocytosis does not obtain in time to counteract the effect of implantation of septic germs which could thus gain a foothold, and more certainly cause suppuration than in ordinary hypodermatic injection.

"A case of sloughing has been brought to my notice in which the Schleich method was used for anæsthesia in operation for mammary abscess. The infiltration fluid was prepared by a local druggist; the infiltration was made by the physician with a hypodermatic syringe and needle used for ordinary medicinal injection. 'Anæsthesia was complete, but operation was followed by sloughing of the whole surface of the skin injected.'

"Schleich does not report any such cases at his hands. In several hundred injections that I have made, I have had no trouble. Reports coming to me from other surgeons do not chronicle such an event, which can only be the fault of the

operator. Schleich has pointed out in his brochure and in his other writings that absolute sterilization of everything in connection with the procedure should obtain. I have referred to this in my own articles. I would emphasize the following points:

"I. The ingredients of the solution should be made absolutely sterile. This may only be obtained by *boiling all the solutions for five minutes before each operation* (afterwards cooling the same). The factor is especially pertinent, as leading manufacturing chemists in the United States and Germany have infiltration tablets on the market for extemporaneous preparation for the several fluids. The tablets themselves are presumably aseptic, but if fingered ever so slightly cannot remain pure. *Boiling the solutions after mixing does not interfere with their anæsthetic qualities.**

"II. The bottles, corks and stoppers containing the solutions, the dishes used in which to pour out small quantities of the solution, should all be previously boiled (or sterilized by heat), and not suffered to remain exposed to contaminating influences, not even the air, but should be covered after cooling.

"It is even more necessary for instruments, etc., to be aseptic than for ordinary operations. Any good hypodermatic syringe and needle may be used, but should be previously prepared by immersion for at least one-half hour in a five per cent. carbolic solution, which may be removed before operation by washing in sterilized water. The finest and sharpest of needles are advisable. These may be sterilized by boiling in soda solution or by carbolic immersion.

"The person preparing the solution should prepare his hands, as well as the surgeon, as carefully as if for an abdominal operation. The part to be operated upon should be made aseptic in the usual manner. Attention to detail is absolutely necessary for the success of healing as well as for anæsthesia.

"It is the fault of the operator if he does not secure perfect anæsthesia and aseptic infiltration, followed by good healing."

Messrs. John Wyeth & Brother have prepared from the formulæ of Dr. Schleich a series of soluble compressed tablets, which can be obtained from any regular pharmacist.

* It is a well recognized fact that boiling destroys the cocaine, so it is to be added when cool.

The advantages of these soluble compressed tablets are manifold. They are at once soluble, are made of the several desired strengths, are permanent and stable, the solutions can be prepared in a moment, the fear of septic infection from stale solutions is entirely removed, the operator can always be supplied with more than sufficient for any emergency, and the combined ingredients do not deteriorate or change by age or climatic influences. We feel there is a wide field for the use of this method, not only in the hands of surgeons, but with the general practitioner, for the relief of local pain, and to the dentist they will prove an invaluable aid.

The following are the sizes of these soluble compressed tablets:

Tablets to Make 100 Minims of Solution.

No. 1.—Strong.

Cocaine hydrochlor., ...	1-5 grain.
Morph. hydrochlor., ...	1-40 grain.
Sodium chloride, C. P., ...	1-5 grain.

One tablet dissolved in 100 minims of water yields the Strong Solution, representing:

1-500 part of cocaine hydrochlor.
1-4000 part of morph. hydrochlor.
1-500 part of sodium chloride,

or each 1000 minims contain

2 grains cocaine hydrochlor.
1-4 grain morph. hydrochlor.
2 grains sodium chloride.

No. 2.—Normal.

Cocaine hydrochlor., ...	1-10 grain.
Morph. hydrochlor., ...	1-40 grain.
Sodium chloride, C. P., ...	1-5 grain.

One tablet dissolved in 100 minims of water yields the Normal Solution, representing:

1-1000 part of cocaine hydrochlor.
1-4000 part of morph. hydrochlor.
1-500 part of sodium chloride,

or, in other words, each 1000 minims of this Solution equal:

1 grain cocaine hydrochlor.
1-4 grain morph. hydrochlor.
2 grains sodium chloride.

No. 3.—Weak.

Cocaine hydrochlor.,	1-100 grain.
Morph. hydrochlor.,	1-40 grain.
Sodium chloride, C. P.,	1-5 grain.

One tablet dissolved in 100 minims of water yields the Weak Solution, representing:

1-10,000 part of cocaine hydrochlor.
1-4000 part of morph. hydrochlor.
1-500 part of sodium chloride,

or each 1000 minims of Solution contain

1-10 grain cocaine hydrochlor.
1-4 grain morph. hydrochlor.
2 grains sodium chloride.

Should more than 100 minims be required, use one tablet for every 100 minims of water used.

Tablets to Make 500 Minims of Solution.

No. 4.—Strong.

Cocaine hydrochlor.,	1 grain.
Morph. hydrochlor.,	1-8 grain.
Sodium chloride, C.P.,	1 grain.

One tablet dissolved in 500 minims of water yields the Strong Solution.

No. 5.—Normal.

Cocaine hydrochlor.,	1-2 grain.
Morph. hydrochlor.,	1-8 grain.
Sodium chloride, C.P.,	1 grain.

One tablet dissolved in 500 minims of water yields the Normal Solution.

No. 6.—Weak.

Cocaine hydrochlor.,	1-20 grain.
Morph. hydrochlor.,	1-8 grain.
Sodium chloride, C.P.,	1 grain.

One tablet dissolved in 500 minims of water yields the Weak Solution.

Should more than 500 minims of solution be required, use one tablet to every 500 minims of water.

In cases where the Solution is desired to be stronger or weaker

than the Normal Solution, but being of the same relative proportions of Cocaine, Morphine and Sodium Chloride as in the Normal Solution, all that is necessary is to either increase or decrease the quantity of water to be used to each tablet of the Normal Recipes No. 2 and No. 5.

Special attention is called to the fact that in the Normal (No. 2), Strong (No. 1) and Weak (No. 3) tablets only the Cocaine Hydrochlorate varies, while the Morphine Hydrochloride and the Sodium Chloride are the same amounts in all three recipes. This also applies to Nos. 4, 5 and 6.

The Tablets are put up in tubes of 20 tablets each, in cases holding 10 tubes, and also in larger packages, such as 100's, 500's and 1000's.

Dr. Bransford Lewis, of St. Louis, in an article in the *Medical Standard*,* giving his experience in the use of this method, cites the following practical points:

"Every tissue of the body, without exception (skin, muscle, gland, mucous membrane, nerves, etc.), becomes insensible to pain when infiltrated in the manner described. This obtains for bone and the hard structures as well as the soft ones. Bone is reached either through infiltrating its periosteum or by injecting into the medulla. Nerve trunks are anæsthetized separately, first by applying 5 per cent. carbolic acid solution, and then through this inserting the needle and fluid.

"Only the infiltrated, artificially œdematous tissue is anæsthetic, the tissues just outside retain normal acuteness or insensibility. Consequently in the course of an operation, with absorption of the infiltrated fluid, it is necessary to renew the injections or extend their area coincidently with the operative fluid.

"With the proper fluid anæsthesia ensues immediately on its being introduced into the tissues, and lapse of time is not requisite for developing insensibility. This again is in marked contrast to the effect of the older methods of producing anæsthesia. Its advantage is great.

"Anæmia resulting from the method, there will be less

* Medical World, p. 41, February, 1896.

bleeding (oozing) than under ordinary circumstances. Distortion of the tissue from the infiltrated fluid does not cause any especially increased difficulty in securing and tying or twisting bleeding vessels. Nevertheless, in operating in deeper structures, care must be taken to avoid risk of piercing blood-vessels, nerves, etc.

"Strong solution of cocaine (10 to 20 per cent.) will quickly constringe the vessels and hence will not be absorbed ; while a weak solution (1 to 5 per cent.) will be absorbed and produce systemic poisoning."

The Use of Cocaine Upon the Nasal Mucous Membrane Prior to and During Anæsthesia.

Rosenberg, in an article published in the *Berliner Klinische Wochenschreft*, Nos. 1 and 2, 1895, advocates the use of cocaine upon the nasal mucous membrane prior to and during anæsthesia, claiming three-fold advantages:

1. As the patient's perception of the odor of the anæsthetic is much diminished, the feeling of suffocation is entirely absent.
2. The stage of excitement is either shorter or entirely absent.
3. Vomiting during narcosis is rarer than usual.
4. Sickness following anæsthesia does not occur.

Gerster reports the results in 100 cases where this method was employed in the operating room of the German Hospital, New York.

A 5 per cent. solution of cocaine was used. The patient freed his nose from mucus, and 2 minims of the solution were sprayed into each nostril. Two minutes later the process was repeated, one-half of the quantity being employed. Every half-hour during the operation the nose is again sprayed and, for the last time, just before the patient leaves the table.

In 52 cases chloroform was given ; ether in 24 cases ; and the A. C. E. mixture in 13 cases. In the other cases more than one of these anæsthetics were employed. It was found that the cocaine diminished considerably the distress and oppression felt by the patient at the beginning of the anæsthetic, and that the reflex irritation, as manifested by struggling, coughing and nausea, is diminished.

In from 10 to 20 of the cases there were symptoms such as marked pallor and acceleration of the pulse rate, followed by profuse sweating, which were considered directly due to cocaine. There was less nausea, vomiting and malaise than usually follows anæsthesia. Vomiting is recorded as following 25 per cent. of the cases. In alcoholic cases Rosenberg's method affords little advantage over the usual anæsthetization. (*American Medico-Surgical Bulletin*, February 8, 1896, p. 192.)

Another method has been proposed by Dr. David H. Loudlon, of Denver. A preliminary spray of the pharynx and nasopharynx with a mixture of ether one part, and liquid petrolatum two parts, with a solution of cocaine if desired. (*The Philadelphia Polyclinic*, February 8, 1896, p. 55.)

CHAPTER XVII.

On the Use of Cocaine in the Teeth, Nose, Throat and Eye.

Every now and then there are reported in the medical journals the most absurd statements of poisoning by cocaine. The following is an example, no name nor journal given: "Suffered from toothache, the tooth being 'dead' and the nerve canal having been drilled out (acted as his own dentist), and concluded to extract, and the tooth broke. Injected the gums with a two per cent. solution of cocaine. (Not stated if freshly made or what the cocaine was dissolved in, alcohol or water, hot or cold. Or if he had the right kind of syringe, which should be longer than ordinary hypodermic, with handles so that sufficient control over the force can be made to penetrate down to the tooth.) Waited half an hour and again injected *about* the same amount of cocaine, and still failed to secure the offending root. It still paining, concluded to inject the nerve canal, and inserted needle and making considerable pressure (irregular), when suddenly the plunger went home, and *about* twenty drops (more or less) of the solution passed into the alveolar

process. Instantly all pain ceased. (Cocaine is not instantaneous in its action.)

"In thirty minutes, however, I had a decided rigor, followed by profuse sweating and vomiting, cold extremities and a terrific headache. These symptoms continued for some forty-eight hours. Not over a drachm (or $1\frac{1}{5}$ gr. of cocaine) of the two per cent. solution was used." All of these symptoms might well have followed such a bungling operation, and not one particle of cocaine need have been employed.

Here is just such another case:

Was it Cocaine Poisoning?

On November 27th I was hastily called to the office of our dentist, and found there a case as follows: Female, about 28 years old, married, and the mother of three children, the youngest about four months old. She had had three teeth extracted (the last one broke), and for a local anæsthetic about forty minims of the following solution had been used:

℞ Cocaine hydrochlor.,	gr. vj.	
Phenacetine,	gr. xxiv.	
Menthol,	gr. v.	
Ether,	m. xxx.	
Glycerine,	dr. j.	
Water,	oz. j.	M.

"As the last one was being drawn she became unconscious and respiration ceased. It was on the opposite side of the village from my office, and when I got there I found her much in the same condition as above described, though the heart's action was good, considering the length of time she had been in this condition. I immediately gave $\frac{1}{60}$ gr. strych. nitrat. hypodermatically, followed with whiskey, and used artificial respiration, and in a few seconds she began to breathe, and after about three-fourths of an hour began to try to talk. After a short time I had her removed to her home, but on reaching there she had relapsed into the same condition as at first, and this time the pulse was so weak that it was scarcely perceptible. I immediately gave $\frac{1}{30}$ gr. strych. nit. hypodermatically and more

whiskey, and in a few minutes she had rallied sufficiently, so I gave her aromatic spirit of ammonia by the mouth, and in another half-hour she began to call for her baby. Did not let baby nurse until next morning, and then not until the breasts had been emptied twice with the breast-pump. On the following day, *i.e.*, on the 28th, I found her sitting up, but she complained of feeling so very tired. She has made a good recovery.

"Now, was it the effect of the fluid used, or did it come from the shock produced by breaking the last tooth? I know it was not all hysterical, and besides, she has never had hysteria in the past. Did the fact that she was a 'nursing woman' have anything to do with the case? The dentist told me he thought she swallowed some of the fluid which leaked out of the syringe and fell into her mouth, and that the gums did not bleed very much.

"I have used cocaine (four per cent. solution), being careful to not exceed ten minims at a time, since I have been practicing medicine, and have used it regardless of the color of the hair and eyes, and have never had any bad results from it."*

In both of these cases there were large doses employed, and the cocaine also swallowed. The hysterical element had also an important influence in these so-called cases of cocaine poisoning. It is well known to all surgeons of any long experience that the most simple operation in minor surgery will be followed by syncope, difficulty of breathing, fainting and prostration, and indeed all the symptoms described as poisoning, as in the above case, all of which can be promptly relieved with aromatic spirits of ammonia and whiskey.

Cocaine is not necessarily a dangerous anæsthetic if carefully prepared with distilled, sterilized water, and used in an absolutely clean hypodermic syringe, for in the last six years there has not been one death due to its use, in the city of Philadelphia. If it is to be kept a short time, add a small amount of phenol, say five per cent. If the patient is feeble, add a minute quantity of morphia and atropia, 150th of a grain, as it sustains the heart action; careful compression by the fingers each side of the tooth, by an assistant, in extraction.

*C. H. Herrick, M.D., Gilbertsville, N. Y., Medical World, January, 1896.

The Use of Cocaine in the Nose and Throat.

There are certainly but few individuals who are so susceptible to the influence of cocaine, that it cannot be carefully applied to the nose or throat by means of a pledget of absorbent cotton charged and applied to the part to be operated upon. By this we are able to determine whether the apparent hypertrophy of the tissues is real or only temporary. We very rarely spray the part, but apply solutions varying from four to ten per cent. If it is simply to diminish secretions, we use the four per cent.; but when a polypus, tonsil, or part of the turbinated bone is to be removed, we increase the solution to ten per cent. In this manner we can apply, without pain, a small ball of chromic acid, chloroacetic acid, or crystals of nitrate of silver. After the production of local anæsthesia, with shrinking of the erectile tissue, in the course of a shorter or longer period there occurs a decided reaction, and the blood returns with great force. To prevent this we spray the part with an alkaline solution, and then with a four per cent. solution of antipyrin. If there is acute or chronic rhinitis, it is treated by spraying the nasal fossæ every other day with liquid vaseline or alboline, in which are dissolved in each ounce five grains of menthol with two of extract of eucalyptus. This local treatment with cocaine we have kept up for the last six years with satisfaction, and with the exception of once in a while as in the case of an hysterical woman, who, after the application of a solution of cocaine to her nasal mucous membrane, will suddenly feel faint, with dilated pupils, extremities cold, and heart action rapid and feeble; but this is soon relieved by placing her flat on the ground, and applying a few whiffs of ether with ammonia to the nostrils, and administering from thirty to sixty drops of aromatic spirits of ammonia internally with water.

Cocaine in Diseases of the Ear.—In our third edition, on pages 86 to 90, will be noted that we have used cocaine very freely in diseases of the ear, and found it of great value in relieving pain within the middle ear when removing diseased structure, bone tissue, and especially in ulcerations, in which we use the curette with the application of powerful agents to the parts with the same precaution as in the throat or nose. We

now but seldom use the general anæsthetic except in deep-seated operations, when the ossicles are removed, or diseased mastoid, or large masses of dead bone. In every instance in which we use cocaine to the ear, especially when the drum-membrane is removed, we apply it by absorbent cotton to the part to be treated, and always after five minutes follow it by the four per cent. of antipyrin sprayed over the part.

When we employ it in the Eustachian tube or in the pharynx, in its vicinity we tip the Eustachian forceps or delicate applicator with absorbent cotton, and then charge it with cocaine solution, avoiding all excess which may pass into the interior. Even when it passes into the œsophagus, we may find a small portion produce only dryness with a loss of taste for a few hours.

COCAINE IN DISEASES OF THE EYE.—The proper method of preventing any injurious influence upon the eye is, in all cases of operation, to use the solution of two to four per cent., which should be made fresh each time it is required. The packing of the hypodermic syringe is also to be cleansed by passing through the same antiseptic solution, as it is apt to become foul. When it is given to a patient as an ordinary eye-wash, a solution of boric acid is made with a minute portion of cocaine added, and this solution is to be employed with a dropper kept in an air-tight bottle and case. The dropper is to be carefully washed out with a hot antiseptic solution of bicarbonate of sodium in boiling water after using it.

Deaths from Cocaine.

In a recent article* by a medical gentleman of experience in the use of this valuable anæsthetic, cocaine, he stated there had been a very large number of deaths from this agent.

Fearing that I might not have an account of all the deaths, I wrote to him, desiring him to be so good as to give me a list from the numerous researches he had made, of any cases of death since my enumeration up to 1890. The following was his kind reply:

* Med. and Surg. Reporter, February 15, 1896.

"February 20, 1896.

"*My Dear Doctor:*

"The following cases of death, due to the injection of cocaine, have come to notice since 1890. There have been, of course, many more during the past five years, but one finds, on looking up the literature of the subject, that many writers have reported numbers of cases at a time, and do not specify the dates, so I cannot state how many cases occurred before and since 1890.

"The Lyons Medical, Lyons, published in August, 1891, a report of a death in a dentist's office.

"Delbose reported five deaths in the Journal de Medicine et de Chirurgie, of Paris, February, 1891.

"In 1892 and '93 Dufournier reported nine deaths in the Archives Generales de Medicine."

This we found to be a mistake, as his last case was September, 1888, and published in October, 1889.

In my third edition (p. 49–55), 1890, there was reported every case of death from cocaine in full up to December, 1889; in all, eight cases, when we went to press, from the time of its introduction in 1855. Most of the cases of death were obtained from a monograph by Dr. Mattison, of New York, and my own examination of every journal published, both of this country and of Europe. The following were my conclusions after a careful study of every case reported. There has been as far as I am informed but one death reported as having occurred in this city.

In a careful reading of Dr. Mattison's before-referred-to monograph we found a few points on which we wanted a little more definite information, and wrote to him for that purpose, but received no reply. The name of the journal in which were given the details of the Russian surgeon's case is not reported. Might not the operation of scraping and cauterizing a tuberculous ulcer have caused the death of the young woman? Was not three-quarters of an hour a long time before the cocaine had developed its toxic effects? We find, as a rule, they are decided in five to eight minutes. We cannot find the number of the *American Lancet* in which the case is reported by Dr. Long. What was the disease of the larynx? The case of Dr. F. M.

Thomas was not reported in any medical journal. Judging from the symptoms, the woman died from paralysis, and had been under treatment for the same. We were unable to find where Dr. Knabe's case was published. Such cases frequently die from cardiac degeneration followed by dropsy, the result of scarlatina; the dose was so small, only four to twelve drops —the exact amount not determined—of a four per cent. solution. Now we come to the case of Dr. Simes, of Philadelphia. In reading this case over carefully we are of the opinion, from the symptoms and post-mortem record, that the man had been an epileptic; and again a twenty per cent. solution is too strong, and should never be employed in the urethra or rectum,* as it enters the veins by endosmosis, and it also acts upon the spinal nerve, and has been found a true cerebro-spinal excitant in large doses. The dose internally is one-sixth, one-fourth, one-third of a grain. We find that with a two per cent. solution, with acid carbolic gr. x. to the oz., we obtain all the results we desire if repeated, and if possible controlled by position, or a ligature, as suggested by Corning, of a rubber tube.

The case reported by Abadie is very imperfect in its details and cannot be received until further information is obtained, still we consider it our duty to publish all the cases of alleged deaths, so as to induce a proper caution in persons who have never employed the drug, just as we do in prescribing morphia and other powerful alkaloids.

In the two cases reported by "Lanianchi and Montalli" the first was an epileptic and the second one afflicted with phthisis. In one case Montalli gave in mistake twenty-two grains of the drug.

Reclus reported to the Société de Chirurgie, 21 Mars, a case of death from cocaine. It occurred in the hands of another doctor. The patient was a man, aged 72 years, affected with enlarged prostate and retention of urine. Aspiration was performed, and the next day, it having been found again impossible to enter the bladder through the urethra, he injected twenty

* Six grains has produced poisonous symptoms when employed in the rectum.

cubic centimetres of a five per cent. solution of cocaine. The man was at once seized with tremors, became pale, and succumbed in a few minutes. Reclus states that, as a general rule, a two per cent. solution only should be injected, and not more than fifteen to twenty centigrammes of it at a time. If these two rules had been observed the accident would not have taken place.—*La Tribune Medicale*, March 29, 1894.

Being desirous of obtaining the record of deaths from cocaine and verifying those cases of deaths which I had obtained up to the time of my edition of 1890, I wrote to my friend, Dr. Marcel Natier, of Paris, who most kindly sent me the *Arch. General de Medicine*, October, 1889, which I found contained three extra cases, making in all eleven deaths, which were as follows:

Case 9.

An interne of the University College Hospital had ordered 1 gram. 25 cent. gram. of cocaine with the intention of injecting it into the bladder of a man, 30 years of age, troubled with acute cystitis. Unfortunately he had neglected to state the use of the drug on his prescription and the druggist delivered it, telling the nurse it was probably a potion. It was given as such, and the patient succumbed.

It was not at first pronounced an accident, but at the end of a half-hour convulsions set in, and from those he died.—*Bull. Med.*, 24 Fevrier, 1889.

This was a case of direct poisoning by the use of over 15 grains, and no means employed to prevent its fatal effects.

Case 10.

A woman swallowed by mistake 5 grammes of a solution of chlorohydrate of cocaine, 30 per cent.

A quarter of an hour after the ingestion the patient was taken with a spasm of the throat, nauseated without vomiting. The lips became cyanosed, the pupils dilated, the pulse almost imperceptible, and the patient succumbed amidst convulsions.

At the post-mortem a small cavity was found in the right lung, with a slight fatty degeneration of the heart. The brain,

the meninges and the abdominal viscera were congested. (Montalli, *Lo Sperimentate*, Sept., 1888.)

A more recent case of recovery was reported by Dr. M. V. Ball, of Philadelphia, where a patient of his, with a suicidal intent, swallowed a solution of cocaine (6 drachms), of a five per cent. solution of cocaine, equal to about 18½ grains. Recovery took place under the use of black coffee; strychnine, $\frac{1}{30}$ grain, was administered by the mouth, and some champagne was given. The early administration of $\frac{1}{3}$ of a grain of morphia did probably influence the course of the case.

I am also indebted to Dr. Natier* for the following death which have occurred since 1890, only three cases in six years, and which confirm my observations that in the proper selected cases and the exact dose, not to exceed $\frac{1}{2}$ grain, it will be found the most valuable local anæsthetic that we can employ, especially when associated with small quantities of morphia and chloride of sodium in solution.

Dr. Bergu relates the history of a man who, in October, 1891, was operated upon at the Hospital Lariboisiere for a simple hydrocele, of medium size, of two months' duration. He used an injection of iodine after anæsthesia of the vaginal tunic, by means of a soupspoonful (probably a tablespoon—about 250 M.—5 grains) of solution of hydrochlorate of cocaine, fifty per cent. After twenty minutes' rest, the patient left the hall, but returned ten minutes later, feeling indisposed; went into a state of syncope, followed by convulsions and pupillary phenomena.

Injections of ether, artificial respiration, tracheotomy, inhalations of oxygen, all were useless, and death followed rapidly. The well-known and usual clinical and experimental symptoms of cocaine poisoning were well manifested. The autopsy made by Dr. M. Richardson (who had already reported medico-legally 11 cases of death from cocaine, all that he could collect since its introduction) revealed no mortal lesion. There was only

* Dr. Marcel Natier, Chef du Service des Maladies du Nez, des Oreilles et du Larynx a la Polyclinique de Paris; Editor Revue International, Rhinologie, Otologie and Laryngologie.

congestion of the brain and lungs. There was a slight mitral insufficiency in the heart, which, perhaps, favored the accident, but could not have had an important effect. The dose of cocaine, however, was not extraordinary—usually one puts in the tunica vaginalis o. g. So. of cocaine for 30 grammes of water. Perhaps the thin coating of this acute hydrocele absorbed the drug with unusual rapidity. In any case, M. Bergu, who, after numerous operations, would have affirmed, some weeks ago, the absolute harmlessness of this procedure, declares, without denouncing cocaine, that at his next hydrocele he will hesitate.

M. Reclus believes that the maximum dose employed by Hœnel is dangerous; that even 0 gr. 0.3 cent.—which was the quantity used with M. Bergu's patient—is also dangerous. In Dr. Reclus' first experiments he uses the doses of 0.3 cent.,* and has had now and then serious enough accidents. He does not exceed 0 gr. 20 cent., and he usually injects into the hydrocele—not evacuated—a 0 gr., .05 cent., on 0 gr., .075 cent., a syringeful, and has never had the slightest alarming symptoms, while anæsthesia has been very well produced. To exceed this dose is both useless and dangerous. It is absolutely necessary to recognize the possibility of danger from rapid absorption through the thin coating of an acute hydrocele.

* The French use the abbreviation gr. to signify gramme and c. for centigramme.

CHAPTER XVIII.

Therapeutics of Cocaine—Gastritis produced by Poisoning treated by Cocaine, and Affections of the Stomach, Tetanus, Skin Disease.

Cocaine in Gastritis Produced by Poisoning.

In a recent case published by a physician* in Scranton, Pa., a young girl, after an unsuccessful attempt at suicide by laudanum, took "Rough on Rats." She was given ipecac and sulphate of zinc; also large quantities of dialized iron and lime-water. Two grains of morphine were administered hypodermatically in divided doses during the night, and the woman was kept anæsthetized by means of chloroform and ether for twelve hours. Whenever the anæsthetic was withdrawn, the patient would rebel, and was with difficulty held by three persons when not profoundly under the influence of ether. Twelve hours after the poison had been taken, the girl was still in terrible agony, and showed signs of collapse. It was suggested by another physician that over half an ounce of a four per cent. solution of cocaine hydrochlorate (about ten grains) should be administered, it being supposed that all the arsenic had been vomited or neutralized, and that gastritis had set in. In a few minutes the patient ceased to complain of her stomach, the mania subsided and the anæsthesia was discontinued. The pulse grew stronger, and the woman was soon able to walk with assistance.

Cocaine in Affections of the Stomach.

Cocaine has been found most useful in certain affections of the stomach. From the researches and clinical observations we arrive at the following conclusions: 1. That cocaine exerts on

* Dr. J. Emmet O'Brien.

the mucous membrane of the stomach, and that of the digestive tube, an action as certain as on the external mucous membranes. 2. That for this action to be as complete as possible, one must facilitate the impregnation of the gastric and intestinal mucous membranes by promoting their secretions. Hence the advantage of associating cocaine with alkalies.* For the action to attain its maximum duration, one must add to this mixture very small doses of morphine.

Cocaine in Persistent or Uncontrollable Vomiting.

From the peculiar action of cocaine upon mucous membranes and vascular tissue, it was supposed, theoretically, to be capable of diminishing the sickness of pregnancy and other severe irritation of the stomach of a reflex character. It has been tested in a number of cases with more or less success.

Cocaine in Lavage or Gavage.

In the act of inserting the stomach pump or tube there is almost always pain and spasm, due to the contractions which take place on the isthmus of the fauces, which may be obviated by painting with a two per cent. solution of cocaine. It has been found very valuable in certain spasmodic and even permanent stricture of the œsophagus; where dilatation is required, a two per cent. ointment is applied to the tube.

Cocaine in Boulimie or Insatiable Hunger.

This peculiar intense and insatiable hunger or canine appetite is peculiar to pregnancy, and can in some cases be relieved by small doses of hydrochlorate of cocaine, $\frac{1}{20}$ to $\frac{1}{10}$ or even $\frac{1}{4}$ of a grain taken at intervals, in pill form, while in the recumbent posture.

* It must be remembered that caustic alkalies decompose the cocaine.

Tetanus Treated by Morphia and Cocaine.

Lopez is quoted by the *Journal of Nervous and Mental Diseases*, for December, 1887 (*Medical News*, January 28, 1888), as reporting in an Italian journal the following case: M. G., fifty years old, having worked in the cold and wet, complained of rheumatic pains in the back and extremities. Three days after he had an attack of opisthotonus, painful spasms and all the symptoms of idiopathic tetanus. Morphine and chloral hydrate were prescribed. For three days the patient, under the influence of these medicines, had little pain; but there was increased muscular rigidity and spasms. At last he was unable to swallow, and death was believed imminent. Injections of morphine were without effect. Then the writer injected three syringefuls of a mixture of morphia and cocaine, five per cent. of each. The effect was immediate. After two hours he could move the extremities, open his mouth and turn himself in bed. The next day he continued to improve. There remained a slight trismus and a little rigidity of the neck. A quarter of a syringeful of the same solution was injected in each side of the neck, and the day after all the symptoms had disappeared.

Cocaine in Skin Diseases.

Lustgarten (*Wiener Med. Wochenschrift*, November 12, 1887) states, what we demonstrated soon after cocaine was discovered, that where the epidermis is in contact, cocaine applied to the skin is not absorbed; but where the horny layer is thin or absent (removed by alkalies, alcohol or chloroform), it acts. A two per cent. solution used several times daily allays the itching in acute and subacute eczema, being especially valuable in eczema of the anus and genital regions of both sexes. In the form of ointment he employs oleate of cocaine, from 6 to 15 grains; lanolin, 4½ drachms; followed by the use of a dusting powder (two of the best are finely-powdered talc or lycopodium). In pruritus ani, suppositories may be made containing three-fourths of a grain of oleate of cocaine. The author cautions against the toxic effects of cocaine, three cases of this kind having been encountered when only three-fourths of a grain had been used.

Treatment of Chilblain.

Apply with cotton or wool a four per cent. solution of cocaine for ten minutes; then remove the cotton and cover the parts with compound tincture of benzoin. This repeated a few times will entirely relieve the pain and irritation. A valuable ointment for the same disease is equal parts of oil of turpentine and compound rosin ointment. Apply by rubbing in the ointment near a hot fire at bedtime. Another salve is recommended by Dr. Lassar:

℞ Acid carbolic cryst.,		gr. xv.
Ung. plumbi,		ʒv.
Lanolin,		ʒiiss.
Oil amygdal., Oil lavend.,	āā	gr. xx. M.

Cocaine in Intense Itching of the Skin.

In the various forms of pruriginous affections of the skin, cocaine with vaseline or a two per cent. solution in alcohol will allay the distressing itching of the skin.

Cocaine in Burns.

Either the solution, or ointment of cocaine, has the great advantage of dissipating the intense pain of severe burns when in a two per cent. solution.

Cocaine in Anal or Vulval Pruriency or Painful Herpes.

℞ Cocaine oleat.,	40 to ½ gramme (gr. viiss. to xvss.).
Lanolin,	18 grammes (ʒv.).
Ol. oliv.,	2 grammes (gr. xxxi.).

To be used several times a day.

—*Gaz. Hebe. des Sci. Mede.*, Montpelier, Jan. 14, 1888.

Cocaine in Cracked Nipples.

A two per cent. powder of hydrochlorate of cocaine and starch, applied to the fissure in the nipple of nursing women;

covered with collodion, will relieve the distressing pain. The same good results follow fissures of the skin of the hands during very cold weather. A few inveterate cases require first to touch the fissures with a fine pencil of nitrate of silver very gently.

Cocaine in Acute Catarrh, Coryza, or Cold in the Head.

In acute catarrh, or cold in the head, we have a condition of engorgement of the blood-vessels in the nasal mucous membrane, and the secretion, which at first is thin and watery, through hyperstimulation of the glands, soon becomes more charged with broken-down epithelial cells, lymph corpuscles, pus globules, etc., until it assumes the character of thick, tenacious mucus, or muco-pus. If cocaine be applied early to the membrane in a case of acute coryza, its constringing influence on the membrane must diminish the blood supply, and thus prevent the engorgement and transudation. We have personally tested its abortive action in an attack of coryza.

As soon as the initial stage has passed over, and secretion commenced, a four per cent. solution should be applied freely over the interior turbinated bones of each side.

As is well known, the coryza of nursing infants and young children may, by preventing suckling, prove a very serious affection. It can be cured, however, by the introduction into the nasal cavity, six times daily, of a one per cent. solution of the hydrochlorate of cocaine, on cotton, for five minutes. According to the author, children who previously had obstinately refused to nurse will commence to suckle a few minutes after the first application of the cocaine, and the coryza is ordinarily cured after about four days of this treatment.*

℞	Hydrochlorate of cocaine, ...	$\frac{1}{2}$ gr.
	Very finely powdered starch, . . .	49 grs.
	Mix intimately.	

SIG.—Use at intervals of about an hour until relieved.

* This treatment is made more successful by the spray of the antiseptic tablets of Dr. Seiler; also useful in hay fever to cleanse the parts.

Cocaine in Hay Fever.

Sir Andrew Clark prefers to use a solution of five per cent., applying it to the interior of the nose and back of the soft palate, by means of a large camel's-hair pencil attached to an aluminium shank, and bent at an appropriate angle. For use in the form of nasal bougies a quarter of a grain or more of the hydrochlorate of cocaine is dissolved in a mixture of gelatine and glycerine, and made of different weights and shapes, according to the peculiarities of the case on which they are to be employed.

Cocaine and Phosphate of Lime in Laryngeal Tuberculosis.

Professor John Schnetzler used phosphoric acid in different degrees of concentration, even in full strength, applied by means of a brush or the syringe to the larynx, producing pain in some cases, which he obviates by the use of the following powder:

℞	Cocaine mur., ...	0.1 (gram.).	
	Calci. phosphor., ...	100	
	Ol. menth. pip., ...	gtt. v.	M.

Use by insufflations.

Though the remedy has no specific influence on the tubercular process, relief (and under favorable conditions also recovery) has been obtained in several cases; it is also an excellent remedy in all catarrhal affections of the upper air passages.—*Jour. Am. Med. Association*, January 21, 1888.

Cocaine in Whooping-Cough.

Dr. Weintraub, of Eydknhuen, prescribes the following formula, with good results:

℞	Cocaine muriat., ...	gr. j. ½ to 1 gr.	
	Aqu.-amygd. amar., . . .	℥iiss.	M.

Sig.—Ten to fifteen drops several times a day.

—*Alg. Med. Central Ztg.*, 91, 1887.

Cocaine and Resorcin in Whooping-Cough.

Resorcin has been found one of the most available remedies in pertussis, relieving the bacterial origin of the disease. Since 1885 cocaine has been used as a preliminary to the resorcin, as we found that it lessened the intensity and frequency of the cough before the resorcin had time to destroy the morbific germs. We use a four per cent. solution and an eight per cent. solution of resorcin ; and this combination constitutes the best treatment for whooping-cough now at our command.

Cocaine Mixture for Relief of Cough and of Chronic Pharyngitis.

The following formula has been recommended for the relief of the cough in chronic pharyngitis:

℞ Cocaine, ... gr. iss.
Glycerine, ... f ʒj.
Aquæ dest., ... f ℥x ʒij.
Acid carbol., ... gr. $\frac{1}{6}$.

SIG.—Apply morning and evening with a suitable brush.

—*Medical News*, April 11, 1885.

Cocaine by Insufflation and Inhalation.

A. Inhalation.

℞ Cocaine hydrochlor., ... gr. iij.
Potassii chlorat., ... ʒij.
Aquæ laurocerasi, ... f ℥xij. M.

B. Insufflation.

℞ Cocaine hydrochlorat, ... gr. j.
Morphiæ hydrochlorat, ... gr. j.
Bismuth sub-nitrate,
Sacch. alb., ... āā . . ʒj. ij.

Cocaine in Paroxysmal Sneezing.

℞ Sol. of hydrochlorate of cocaine (4 per cent.), ʒj.
Acid carbolic, ... ʒj.
Tinct. camphora, ... ʒiss.
Aquæ, ... ʒij. M.

Lotion. Syringe or spray the nostrils each morning with posterior nasal syringe or spray apparatus.

Dr. Da Costa (*Med. and Surg. Reporter*, Nov. 7, 1885), having found solutions of cocaine favorable in rose cold or hay fever, concludes as follows: That the remedy is not radical, and, strictly speaking, curative. He has found that it gives great comfort, converts severe into light cases, enables to remain in their homes those who otherwise are obliged to flee to hay fever resorts, and relieves much suffering and distress.

After the suffering and distress are relieved by the cocaine we have found permanent relief from the spray of a solution of peroxide of hydrogen, one-half ounce to half a pint of pure water. The spray apparatus must be of glass or rubber, as all metallic contact destroys the peroxide of hydrogen.

Cocaine in Asthma.

Mosler, of Greefswald (*Birin. Med. Review*, p. 236, Nov., 1886), points out that cocaine has a central as well as a peripheric local action on the sensory nerve endings, and this central action is at first stimulating, but afterward sedative or narcotic. By both these reactions cocaine ought to be of use in asthma. Beschorner has published two cases in which it was of service, and Mosler in three cases has obtained excellent results. All these were uncomplicated, and occurred in young people of twenty-three to twenty-five years of age. The drug was given subcutaneously in two per cent. solution.

CHAPTER XIX.

Cocaine in Diseases of the Eye and Ear—Eucaine Hydrochlorate, a New Local Anæsthetic.

The best antiseptic solution of cocaine contains gr. $\frac{1}{20000}$ of bichloride of mercury, and may be employed after keeping a few days, if made with pure distilled water. I have found that a strong solution will cause a feeling of roughening, and will detach the epithelium of the eye. This will require an infusion of pith of sassafras, with camphorated tincture of

opium (a teaspoonful in a coffee cup of the tea), to relieve the disagreeable symptoms. The cocaine should be a two per cent. solution, and freshly made when required.

The question of using a *freshly-prepared solution* is of the utmost importance. Cases of irritation and inflammation often occur after using solutions too strong or containing mould. Likewise the syringe must be kept scrupulously clean, and after washing and wiping, draw a few drops of equal parts of olive oil and liquid carbolic acid up and down the needle, then wipe it dry.

Cocaine in Diseases of the Eye.

Five cases of ordinary catarrhal conjunctivitis were treated successfully, but not worthy of being reported in detail.

Case Sixth.—Case of cyclitis in a young lady of sixteen, C. G., at school, with extreme pericorneal congestion. The pain in the eye was very much relieved by dropping in a two per cent. solution of the hydrochlorate of cocaine, and congestion disappeared as if by magic. She was directed colored glasses, and not to use her eyes; when the pain returned, to drop in one or two drops of the same solution.

Case Seventh.—A gentleman, T. L., aged sixty years, with catarrhal conjunctivitis, which attacks him during autumn and remains most of the winter, increased by cold winds and reading by gaslight. He was suffering from a discharge in the morning and burning through the day. I applied a two per cent. solution to the eye with a brush, when he complained of a slight smarting for a few seconds. After the smarting had disappeared, he bore without flinching a solution of boro-glyceride to get rid of the excessive secretions which blurred his vision at night. It also removed the red and irritable appearance of the edges of the eyelid.

Case Eighth.—This case is similar to No. 6, only in a lady of thirty-nine, who has a great deal of writing to do, and is employed in a book-bindery; but a few applications of the two per cent. solution relieved her.

In two of the eye cases, dilatation of the pupil took place; but not for some time after full application; it caused slight dryness, but did not interfere with the vision.

Case Ninth.—Case of acute coryza without pain, but sneezing, complained that when the solution was applied by means of a dropper it caused her pain, but there was no return of painful sneezing, which is in certain families the forerunner of the swelling of the mucous membrane with cold in the head.

Case Tenth.—A gentleman, aged thirty-seven, who has a broken nose and a hypertrophic catarrh on very slight exposure, was attacked on the evening of the 23d of January with great oppression. Having to ride in the country in an open carriage and stand in mud and ice for some hours, he returned in the evening with a feeling of great distress and pain in his head, and mucous membrane of the nasal passages much swollen. Two applications of a two per cent. solution of the hydrochlorate to the whole surface of the posterior nares at intervals of five minutes, followed with a five per cent. solution of the alkaloid in oleic acid, gave him great relief, so that he could breathe with comfort and satisfaction. He was then directed one-eighth grain of morphia sulphas, and one-hundredth of atropine, to be taken at bed-time.

24th.—Still suffering somewhat from the difficulty of the breathing through the nostrils, but a repetition of the application of the oleate relieved him entirely.

January 26.—Discharged the patient, cured.

Case Eleventh.—Catarrhal inflammation of the eyelids, known as blepharitis marginalis, with defective vision, in a school girl, aged ten years. The crusts around the eyelids were removed twice with a warm two per cent. solution of cocaine, after resting for a time; then the eyelids were painted with a solution of boro-glyceride; these two preparations used together entirely removed the redness and gave great relief to the little patient. She was directed to continue the use of the solution of boro-glyceride for some time, not to use her eyes, and wear smoked glasses when in the sun.

Cocaine in the Treatment of Gonorrhœal Ophthalmia.

Mr. A. Leahy reports (in the *Indian Med. Gazette*, July, 1886) two cases of gonorrhœal ophthalmia, in both of which

the greatest benefit was derived from application of cocaine. As it is well known, in gonorrhœal ophthalmia it is of primary importance to lessen the inflammation rapidly, to relieve the intense congestion of the conjunctival vessels and reduce chemosis, and by so doing prevent ulceration and sloughing of the cornea. Last, but not least, is the relief of the ocular and circum-orbital pain, which, by its persistence, greatly depresses the patient and prevents sleep. Mr. Leahy employed a mixture composed of one-half grain of sulphate of atropine and two grains of sulphate of cocaine incorporated with one hundred grains of vaseline. This mixture was introduced beneath the upper eyelids, and after three days' treatment the chemosis rapidly became less, the discharge diminished in quantity, the pain completely disappeared, and the cornea, which had been hidden by the chemosis, became visible.

Cocaine and Atropia for Iritis.

Guaiaila gives the following as used by many ophthalmologists:

℞ Cocaine hydrochlor., ... gr. ½.
Atrop. sulphat., ... gr. 1.
Acid boric, ... gr. iv.
Aquæ destillat., ... ʒiiss. M.

SIG.—One or two drops in the eye every half hour until the pupil dilates.

—*L' Union Medicale*, June 25, 1887.

On the Use of the Solution of Cocaine Hydrochlorate in Ear Disease.

Nov. 20, G. B. M., M.D., applied for deafness in both ears, but especially the right. On examination found the sides of meatus and lumen filled with separated masses of scales several millimeters in length, firmly attached to the parts, which, on removal by the forceps, gave him great pain. He also found the pressure of the ear speculum painful. This was explained after the removal of a portion of these diseased scales by finding the under surface inflamed, reddened, and ready to bleed at the slightest touch of the instrument. To obviate this pain and

allow the entire removal of this desquamated material, a four per cent. solution of hydrochlorate of cocaine was instilled into the ear every five minutes for fifteen minutes. At the end of this period, again began removing the offending material without so much pain; still it was not a true anæsthesia, and if we made strong pressure with the speculum in introducing it, it also gave him slight pain; still he was able to bear it much better with the solution, until all was removed from the right ear. He was then directed a sol. zinci sulpho-carbolate, grs. iv.; morphia sulphas, grs. i.; iv. oz. of aqua destillata. For the left ear, after the use of the forceps, gave an alkaline solution to drop in ten drops three or four times a day and rest for fifteen minutes so as to remove what scales were on the m. tympani. November 23, washed out the remaining scales, and inflated the middle ear, with great improvement of hearing in both ears.

November 25th, H. F. M., aged 29, bank clerk, suffering from deafness and constant "rattling or buzzing," from congestion and hypertrophy of the pharyngeal tonsils and mucous membrane of the post-nasal spaces, which required cutting freely with a tenotomy knife. Before doing so I applied a four per cent. solution of the cocaine, and although I made five different incisions into the enlargement, he was not aware that it was accomplished until he found a few drops of blood passing into his œsophagus. One week after he reported by letter of improvement in hearing. In this operation not one-fourth the amount of blood was lost as in such cases without the cocaine, the parts remaining quite rigid for some time after the operation.

November 29th.—Applied the four per cent. solution to a lady suffering from excessive secretions of glands of the throat, and passing into the Eustachian tube causing noises of a variable character. She suffered also from swelling and hypertrophic conditions of the posterior portion of the nasal mucous membrane and turbinated bodies. The parts were cleansed with spray of Dobell's solution, and a strong current of dry condensed air was employed to free them from moisture, a flexible silver catheter was introduced first into the right side of the

nose and a nozzle was fitted to it, and then the elastic tube of the condensed air chamber, and a few drops of the solution of hydrochlorate of cocaine were introduced into the catheter, and the parts sprayed by forcing the air through it. In the same operation performed upon the opposite ear, there being a deviation of the septum, there was more pain, but very much less than when we introduced the instrument before. The spraying was repeated at three different times, when in about ten minutes she felt the peculiar apparent swelling and drying effects, and great relief from the noises, by the freedom with which air passed through the Eustachian tubes. The lady reported, a week after, improvement of hearing and more freedom from the noises.

Eucaine Hydrochlorate.

This is a more recently discovered local anæsthetic, which acts physiologically like cocaine, but is less poisonous. The pulse with eucaine is always decreased in frequency; with cocaine there is primary acceleration. Eucaine causes no ischæmia, but vascular dilatation. Another difference is that the pupils are not affected; midriasis does not occur, and the reaction to light remains normal. The convenient name of eucaine has been adopted in the place of its chemical one of methylester of a benzoylated oxypiperidin carbonic acid. See formula, p. 39. Like cocaine, its free base is with difficulty soluble in water and forms large shining crystals, melting at 104° to 105° C. (220° to 222° F.). With acids it forms neutral salts having the same action as the base itself. The hydrochlorate, the salt which we have employed, crystallizes from a watery solution in permanent shiny plates or scales, which contain one molecule of water of crystallization, and having a formula of $C_{19}H_{27}NO_4HCl.H_2O$.

"*Local Action.*—A two to five per cent. solution of eucaine instilled into the eye of an animal, as a dog or rabbit, caused complete local anæsthesia in from one to three minutes. It began in the cornea, and spread from thence to the conjunctiva, and lasted on an average from ten to twenty minutes. It was readily prolonged by repeating the dose. It was always

accompanied by a slight hyperæmia and slight irritation of the palpebral conjunctiva. This was only the case with the methyl alcohol form; the watery solution caused at most a very slight hyperæmia. The pupil was not dilated, and reacted well to light. Injected under the skin, eucaine caused complete anæsthesia of the part, so that the reflex could not be evoked even with a needle. A similar complete local anæsthesia of the mucosæ was affected when a eucaine solution was painted over it.

"*The general action of the drug*, both in cold and warm blooded animals, consisted in a marked excitation of the entire central nervous system, followed by paralysis in toxic doses going on to death. Even 0.002 cent. gram. ($\frac{1}{33}$ grain) caused irritability, heightened reflexes, inco-ordination, and finally general paralysis in the animals experimented with. Small doses administered to mice and rabbits caused increased reflex excitability and increased but weakened respiratory movements. Medium doses of 0.02 to 0.03 cent. gram. ($\frac{1}{3}$ to $\frac{1}{2}$ grain) per kilogram (35 ounces) caused repeated tonic and clonic convulsions. The animals lay senseless on their sides, with dyspnœa, opisthotonos, and finally paresis of the posterior limbs. These phenomena were most marked when large toxic doses of 0.10 to 0.15 cent. gram. ($1\frac{1}{2}$ to $2\frac{1}{4}$ grains) per kilogram (35 ounces) were administered; the convulsions returned continuously, and affected all the muscles of the body. The animals finally died when the paralysis reached the respiratory muscles.

"When the dose was not a fatal one, the convulsions gradually ceased, the increased reflex excitability disappeared, and the paresis of the hind limbs slowly improved.

"The effect of eucaine on the central nervous system is therefore at first excitant, and later, in toxic doses, paralyzing. The paralysis is a central one, for if the sciatic nerve of a frog poisoned with eucaine is exposed, and its peripheral end irritated with the induced current, the limb reacts in a normal manner.

"As regards its action on the heart and the bloodvessels, the subcutaneous and intravenous injection of small and medium doses slows it on the average from twenty to thirty

beats per minute, but without otherwise modifying the beats, or increasing the blood-pressure. This effect on the pulse is caused by the excitation of the central vagus; for section of the vagi causes an immediate increase of the pulse to the normal and above it, together with an increase of the blood-pressure. Death occurs from paralysis of the respiratory centres, for the heart continues to beat for some time thereafter."*

Eucaine as a Local Anæsthetic.†

"Dr. G. Vinci, of Messina, described eucaine as possessing the properties of cocaine as a local anæsthetic, but as being less toxic and as having no effect upon the pupil. The last statement seemed to me to be of practical importance, because a dilated pupil is an impediment to the performance of many operations upon the eye. It has long been my practice to neutralize the dilating effect of cocaine by a preliminary application of eserine, but this course is not entirely satisfactory. It is difficult to secure the precise degree of effect which is desired, while the eserine dilates the vessels of the iris and occasions free bleeding when they are incised. It also renders the iris tissue comparatively rigid, so that it is less easily drawn out of the anterior chamber. I obtained a supply of a five per cent. watery solution of eucaine hydrochlorate from Mr. Rodgers, of 327 Oxford Street, and used it last week for a cataract extraction, the patient being a woman. Before my arrival the nurse had applied a drop of the solution within the lower lid every five minutes for six times, and I found the eye perfectly insensitive. The pupil was unaffected and acted readily to light. There was scarcely any bleeding from the cut iris; there was perfect quiescence of the muscles and there was no pain. I asked the patient whether she had felt anything, and she replied: 'I felt something moving about my eye, but it did not hurt me.' There was no pain afterwards, and healing was uninterrupted. I have since successfully used a single application

* Pamphlet from Schering and Glaze.

† By Robert Brudenell Carter, F.R.C.S., England, Consulting Ophthalmic Surgeon to St. George's Hospital. From The Lancet, July 11, 1896.

of the same solution as a preliminary to the removal of a foreign body imbedded in the cornea.

"In the original paper it is said that eucaine has been successfully used in dentistry and laryngology, and that solutions may be injected hypodermically without injury. My first experiments will certainly induce me to use it again, and for tenotomies as well as for iridectomy or extraction. It is said that the solution, above mentioned, may be sterilized by boiling again and again, if necessary, without undergoing decomposition or suffering any deterioration of quality."

Eucaine Hydrochlorate in the Eye.

Having had made a careful solution of hydrochlorate of eucaine, two per cent., in distilled water (a second supply obtained from the regular agents, Schering & Glaze), in July, 1896, it was applied to the eye of a patient, and it created both pain and lachrymation, with no soothing anæsthetic after-effects such as is produced by such a solution of hydrochlorate of cocaine.

The following abstract from a letter, addressed to my son, explains this peculiarity:

"Dr. George Merling, the discoverer of eucaine, and likewise a director of the Schering Chemical Works in Berlin, is of the opinion that the irritation was caused by some methyl alcohol contained in the preparation supplied heretofore."

"EUCAINE AND COCAINE.—In the *Therapeutische Monatshefte Blätter* for July 23d, the suggestion is made, in consequence of the burning occasionally caused by instilling a two per cent. solution into the eye, that Berger's plan is followed, that of instilling first a drop of a one per cent. solution, and then, after two or three minutes, a drop of a two per cent. solution. Berger, it is added, uses eucaine and cocaine together, in the following solution:

℞	Eucaine hydrochloride,		
	Cocaine hydrochloride, . . āā . .	3 grs.	
	Distilled water, ...	300 grs.	M.

"The exsanguinating action of the cocaine, often undesirable,

is thus avoided, and its action on the pupil and the accommodation is diminished one-half."—*New York Med. Jour.*, August 18, 1896.

Directions for the Use of Eucaine Hydrochlorate in Dentistry.

"1. Dissolve 1 gramme (15 grains) of eucaine in 10 grammes (150 minims or $2\frac{1}{2}$ fluidrachms) of distilled water and boil the solution. The solution should be perfectly clear, and is best preserved in a glass-stoppered bottle containing about 10 grammes ($2\frac{1}{2}$ fluidrachms).

"2. Thoroughly disinfect the mucous membrane before the extraction by cleansing it vigorously with tampons of absorbent cotton soaked in peroxide of hydrogen or other antiseptic solution.

"3. Insert the needle of the syringe close to the edge of the gum, and never any higher than half-way the alveolar process. Enough fluid must be injected to whiten the mucosa in the immediate neighborhood of the puncture and cause a slight elevation, and no more. Both a buccal and a lingual injection must be made. *It is very important that the injection be not made at the point of junction of the alveolar and buccal mucous membranes.*

"4. Extraction is to be done as soon as the patient himself feels the anæsthesia, which is in about one minute, and not immediately after the injection. It should be done carefully and without the excessive application of force.

"5. After the bleeding has ceased, *the remaining eucaine solution must be removed by puncturing the swelling with the needle and making digital pressure upon the gum.*

"6. Every extraction with resection is followed by some little swelling. When a good deal of eucaine has been employed, and when some of it has gotten under the mucous membrane lining of the bucco-alveolar furrow, we must warn the patient that there will be some swelling, which, however, will be entirely painless, and will retrogress spontaneously in one or two days. The œdema thus set up is entirely harmless; it disappears quickly and without pain, and is never accompanied by any by-effects.

"7. Before making an injection, care should be taken to exclude any air contained in the syringe. That is accomplished by holding the syringe needle upwards, and allowing a drop or two of the solution to ooze out."

Report on Eucaine in Dentistry.*

"DR. LAURENCE TURNBULL:

"*Dear Doctor:* As requested, I have tested the 'eucaine' which you furnished me in such cases as came under my care in the clinic. I also gave some to a gentleman who has a large extracting practice (using cocaine, one per cent.). The solution used in all cases was a two per cent. eucaine in distilled water, and about fifteen or twenty drops injected. It has proven very satisfactory, quite as much so as cocaine, in its local effects, and so far no ugly symptoms have shown themselves. About fifteen persons have had it injected, some for a number of teeth at one time. I did not note the pulse effects."

Dr. A. A. Shaw, dentist, 615 Massachusetts Avenue, Cambridgeport, Mass., states, under date of June 17, 1896: "I have used eucaine hydrochlorate in a number of patients with gratifying results: so much so that I intend to continue its use. I am keeping the records of cases, and expect to make a report of the same for one of the dental journals. One thing I notice particularly is its prompt action and no after-effects."

Dr. Walter Fleming, Hotel Imperial, Broadway and Thirty-Second Street, New York, states, under date of June 1, 1896: "I have used it but once, but that very satisfactory, and I shall continue it in preference to cocaine."

Eucaine in Minor Surgery—Report of a Case.†

"While cocaine has been of undoubted value in minor surgery, its use having enabled the surgeon to dispense with general anæsthetics in lesser operations, many cases have been reported in which its exhibition, even in very small quantities, has been attended with serious and even fatal results. If these

* By Otto E. Inglis, Philadelphia Dental College.
† By Arthur L. Fuller, M.D., Houston, Texas.

accidents were due to the use of excessive quantities of the drug they could be guarded against; but they seem to have occurred quite independently of the amount used, and this uncertainty of action has undoubtedly caused many surgeons to employ it less than they otherwise would have done.

"It is claimed that in eucaine we have a drug which is practically innocuous and which produces a local anæsthesia fully as effective as that of cocaine. While the reports of its use in ophthalmic and dental practice show that it has a very strong claim on our attention, very few reports of its use in general surgery have so far come to hand, and this emboldens me to report a case which is interesting solely from its employment as an anæsthetic.

"Miss J. L., aged 18, came to me with a large mole on her neck. The mole was so situated as to show above the back of her dress, and caused her much distress on account of its unsightliness. After injecting endermically twenty minims of a ten per cent. solution of eucaine, I made an elliptical incision through the skin and removed the mole, together with a little surrounding skin. The piece removed was somewhat larger than a quarter dollar. The edges were then brought together with two sutures and a simple dressing applied. On the third day the sutures were removed and the wound covered with collodion. The place is now, eight days after removal, quite healed, only a thin red line marking the site of the operation.

"In this case the anæsthesia, which covered an area as large as a half-dollar, was rapidly induced and absolutely perfect, the patient not even knowing when the incisions were being made or the sutures introduced, though the tissues were so hardened by the eucaine that it was only with difficulty the needles could be made to pierce it. Such perfect anæsthesia I have never seen induced by endermic injections of cocaine. I observed no bad effects on the circulation, though from the position of the mole there was no means of preventing the whole amount of eucaine entering the circulation in a very short time, and there were no bad after-effects, the wound healing well and quickly.

"This case has given me a very favorable impression of eucaine, and I shall in future almost entirely substitute it for

cocaine in my practice, reserving the latter for those cases in which sutures are required, for while eucaine seems to be the superior in the thoroughness of the anæsthesia induced, it so hardens the tissue that it is only with the greatest difficulty that sutures can be introduced, a drawback which may possibly be overcome by the use of weaker solutions, if such are found to act as well as the one used in this case.

"Since writing the above, my friend, Dr. E. N. Gray, of this city, has described to me a case in which he used eucaine. The patient was suffering from a tubercular ulcer, and he wished to scrape away the diseased tissues. He tried painting the surface of the ulcer with a four per cent. solution of cocaine, but it had so little effect that the patient could not bear the scraping. Some days later he tried an eight per cent. solution of eucaine and was able to curette the ulcer freely with no discomfort to the patient. He states that the anæsthesia was perfect, that it was induced more rapidly, extended more deeply and lasted longer than that of cocaine. His experience coincides with mine as regards the hardening of the tissues, and he informs me that the eucaine coagulated the pus, so that it came away like lumps of cheese."*

CHAPTER XX.

Chloride of Ethyl, or Ether Chlorhydric—Characters. Mode of Preparation, Discovery. Experiments of Clover—Mono-Chlorethane—Wigger's Anæsthetic Ether—Chloride of Ethyl as a Local Anæsthetic—Objections to Powerful Refrigerative Agents—Experiments with Chloride of Ethyl and Pental by Dr. H. C. Wood and David Cerna, M.D.—Compounds, Phenol, Camphor, Menthol, and Resorcin—Antipyrine as a Local Anæsthetic.

The chloride of ethyl (C_4H_5Cl) is a neutral liquid, very mobile; has an agreeable and penetrating odor. Its density at zero — 0.921, boils 12° C. Little soluble in water; very soluble in alcohol. It does not precipitate the salts of silver even

* International Journal of Surgery, vol. ix., September, 1896, No. 9.

in alcoholic solutions. Its vapor burns with a blue flame, producing chlorohydric acid preparation. It is prepared as follows :

We introduce it into a receiver, with two parts of marine salt, pouring equal parts of alcohol and sulphuric acid. It is then slightly heated. Shortly, the chloride of ethyl is disengaged in a gaseous form. It is then washed in a vase containing tepid water, and dried by causing it to pass through tubes containing chloride of calcium, and is finally condensed in a vase surrounded by a refrigerative mixture. The product is very easily altered, and should be preserved in a long narrow-necked bottle, and sealed by the heat of the lamp hermetically.

It is also prepared by the method of M. P. Mounet, of Lyons.*

"In a boiler of iron or steel, with a perforated lid of 200 litres of capacity, there is introduced alcohol pure 92°—55 kilos; acid chlorhydrique, of commerce at 22° Baume—110 kilos. The boiler is furnished with a menometer and a thermometer, and a spigot to disengage or flow off. The boiler is hermetically closed, and the mixture is heated for two hours to 125° C. The pressure on the boiler amounts to 25 atmospheres. Having allowed it to cool to about 60°, they open the spigot, which, by a tube of copper, is put in communication with the boiler and the refrigerant of ice and broken salt, which surrounds the worm of the still. Chloride of ethyl is rapidly distilled. To have it completely pure, it is rectified by passing through water slightly alkaline, and it is then placed in closed glass, ready for use as a local anæsthetic in the proportion of ten grammes each."—*Marcel Baudeun, Progress Medicale.*

Chloride of ethyl was discovered in 1795 by the Dutch chemists Deimann, Troostwyk, Bondt and Lawernburg. Snow employed it as an anæsthetic first in England in 1851, then Simpson, Clover and Nunneley in England, followed by Liebreich, Langenbach and Steffen in Germany, who subsequently availed themselves of it and published their observations. After this then followed researches made by a committee of the British Medical Association, and the following were their conclusions which were reported on the properties of this anæs-

* Anæsthesia. Par A. Auvard and E. Caubet, Paris, Rueff et Co., 106 Boulevard St. Germain.

thetic. The following effects were observed on frogs: Anæsthesia was produced in four minutes, the heart beating naturally for thirty-six minutes; on hot-blooded animals the movement of the heart experienced no modification. A comparative trial was then made between the chloride of ethyl and chloroform on a dog, which demonstrated in the anæsthesia of the chloride of ethyl that the rhythm of the heart was not disturbed, but when the chloroform was substituted the heart became rapidly dilated and beat immoderately, and the cardiac force diminished rapidly. The committee concluded that the dog could live for a longer time under the anæsthetic effects of the chloride of ethyl, while it would soon die under the influence of the chloroform. On man we observe the following effects after inhalation: We notice an agreeable heat which extends over the body. In one or two minutes the sensation becomes confused, with tinnitus aurium and whistling and buzzing. Then a certain muscular rigidity appears and then anæsthesia commences. The patient is longer in becoming conscious than in chloroform, but the after-effects are less. Vomiting is frequent, but is less painful and lasts a shorter time than with chloroform. Clover has made extensive use of it, and has had but one death in 1877 anæsthesias. He prefers to commence the inhalation by the use of the nitrous oxide, and continue by the chloride of ethyl. When you give it alone it is better to continue it alone until the period of agitation is passed, and administer it with prudence, withdrawing it every three or four inhalations. Anæsthesia is induced in between three to five minutes. Dilatation of the pupil will indicate the moment when we should cease the inhalations. See more recent experiments with this agent by Prof. H. C. Wood, on page 445.

MONO-CHLORETHANE.—It is made by the action of alcohol and hydrochl. acid and C_2H_5Cl. It is a gas at ordinary temperature, and is compressed into a liquid; burns with a green flame; specific gravity, 0.918 at 8° C.; boils at 122° C. To be held from six to ten inches away from surface to be sprayed; spray by the heat of the hand. It is highly inflammable. Another chloride is known as the polychlorate or Wigger's anæsthetic ether, which is a mixture of chlorinated ethyl; chlorides chiefly

trihedra and penta. Chlorethane, clear liquid, ethereal; sweet, aromatic taste; local anæsthetic; non-irritant uses; chiefly employed externally in rheumatism and sciatica.

Chloride of Ethyl as a Local Anæsthetic.

The chloride of ethyl is a local anæsthetic, and can be employed without danger sprayed on the skin. It produces a rapid lowering of the temperature of the skin, and a complete anæsthesia of the region touched and its adjacent parts. The surgeon must first cover the skin with a greasy body like glycerine or collodion, to avoid the direct irritating action of the chloride of ethyl, as it sometimes causes a sharp pain in the parts, especially if they have been irritated before.

Objections to Powerful Refrigerative Agents.

The most serious objection to all powerful refrigerative agents is, that they reduce the temperature of the skin and adjoining tissue, and if carried to the condition of an appearance of pork-like nature, when circulation is restored sloughing is very apt to take place, and with it the death of the skin. Our object in employing these agents is to give confidence to the patient that the pain will not be severe, and as small a quantity as possible should be employed.

Chloride of Ethyl and Pental.*

"The editor of the *Dental Cosmos* has submitted to us the two agents whose names head this article, with the request that we should investigate their physiological properties sufficiently to determine the question whether they can be of service as practical anæsthetics. The present paper, therefore, is not an exhaustive scientific study of the physiological action of these two drugs. Chemists are so multiplying compounds, that if each compound is to be thoroughly studied by the physiologist the result would hardly be contained in the world's literature,

* By Horatio C. Wood, M.D., and David Cerna, M.D. Read June 22, 1892. Reprinted from the Transactions of the Philadelphia County Medical Society.

and it is only worth while in the first place to carry these investigations far enough to determine the practical importance of new agents. This much excuse for what may seem, to the pure physiologist, the lack of completeness of the present study.

"In such an investigation as the present, the first point to be determined is whether the substance has anæsthetic properties; the second question is whether the anæsthesia produced is fugacious or permanent; the third question is whether the anæsthesia is accompanied by danger to life.

Chloride of Ethyl.

"Chloride of ethyl is at present largely used as a local anæsthetic agent, which acts not by virtue of any inherent anæsthetic properties, but on account of the intense cold produced by its extraordinarily rapid volatilization. The extreme volatility of the chloride almost proves, *a priori*, that any effect which it may have upon the human system will be of correspondingly brief duration, since very volatile substances are thrown off from the lungs with rapidity. This *a priori* reasoning is entirely confirmed by our direct experiments.

"We have found it difficult, without the construction of special inhalers for the use of large quantities of chloride, to produce anæsthesia in the dog by the ordinary method of administration. The chloride disappears from an inhaler which allows free access of air, almost as fast as it can be poured on. We have used it in two ways. In the one method we connected a large rubber tube with a cannula placed in the trachea of the dog, and then squirted the anæsthetic into the tube in such a manner that it would diffuse itself over the walls of the tube for a considerable distance. The administration in this way of ten grammes of the chloride of ethyl failed to produce distinct anæsthesia in the dog, although the respiration was affected and some fall of the arterial pressure occurred. We append details of two experiments.

"*Experiment* I.—Dog, weight twelve kilogrammes. Given ten grammes by inhalation, thrown into the tracheal tube in about three minutes. During this time the circulation varied at dif-

ferent periods considerably. No anæsthesia was produced. The arterial pressure was at first reduced.

"*Experiment* II.—Dog. Normal pressure, 190 mm.; pulse rate, 120. Ten grammes chloride of ethyl introduced in tracheal tube as rapidly as possible. After an inhalation of twenty seconds: pressure, 185; pulse rate, 144. Seventeen seconds later the pulse began to grow slow and the pressure to fall. Eleven seconds later: mean pressure, 155; pulse rate, 72; the individual waves varying from one to two cm. in height. This condition, with gradual rise of pressure, continued for a minute, when the pressure rose to 190 and the pulse rate to 140. No anæsthesia was produced.

"This experiment shows that the chloride of ethyl is capable of acting as an anæsthetic, provided that its vapor be given in concentrated form. Why anæsthesia was not produced by the second inhalation of ten grammes is not clear, but we believe that it was because air was taken in more freely, owing to the cone not having been placed tightly over the nose of the animal. The results of this experiment indicate, first, that the effect of the drug is exceedingly fugacious, since ten grammes failed to produce a complete anæsthesia of more than two minutes' duration—this, further, in spite of the fact that air was not furnished with sufficient freedom to yield the full supply of oxygen to the blood; second, that the anæsthesia is accompanied with a marked fall in the rate of the pulse and the force of the arterial pressure, the pressure having fallen forty-eight millimetres and the pulse forty-five per minute at the coming of the first anæsthesia, whilst in the third inhalation, shortly after the loss of the reflexes, the pressure stood at ninety, instead of the normal, one hundred and sixty.

"Owing to the comparatively small amount of the chloride of ethyl put at our disposal, in the further study of the chloride of ethyl we confined ourselves to administering the drug by injecting it into the jugular vein. This method of experimentation has the advantage of greater exactness in dosage, and the results are entirely parallel with those which follow the administration of the remedy through the lungs.

"It is plain, that whether a drug be injected directly into the

jugular vein, or whether it enter the system by absorption into the pulmonic capillaries, it must first reach the heart before being diffused throughout the general circulation. In the one case the drug passes first into the right side of the heart, whilst in the other case it goes into the left side of the heart. The anæsthesia which follows the injection of the chloride of ethyl into the jugular vein is very fugacious, as is shown in the following tracing, which demonstrates the effects of the injection of two-tenths of a gramme into the jugular vein. The liquid was injected between the two crosses; the anæsthesia, as demonstrated by the loss of the cornea reflexes, appeared at the first '*o*' and disappeared at '*o x*,' having therefore lasted less than half a minute. It will be seen that the amount of the anæsthetic was sufficient to reduce the circulation to a very dangerous degree.

"The effect of chloride of ethyl upon the respiration is very marked. If the dose has been sufficient to produce anæsthesia, the respiration at first is often stimulated in the extent of the movements as well as in the number per minute. Thus, in one experiment, the normal respiration being 50, the rate became 60; in another, the rate increased from 70 to 80, without, however, any increase in the extent of the movements; a little later in this experiment, the animal still being anæsthetized, the number of the respirations fell to 40 per minute, but became nearly quadrupled in size. In still another experiment the respiration before the injection was 60 per minute, and after the injection, during the early anæsthesia, was still 60 per minute, but the excursions of the needle connected with Marey's tambour were three times the size of what they had been before the administration of the drug. In a fourth experiment the respirations before anæsthesia were 70 per minute; during the early anæsthesia, 120 per minute; a few seconds later, 100 per minute; the movements of the needle being at the same time enormously increased.

"In all our cases the fall of blood-pressure, after the injection of chloride of ethyl, has been immediate and excessive; the blood-pressure has continued low without rise during the whole period of anæsthesia, but has returned rapidly to the normal as

anæsthesia wore off. The cardiac beats have always at first been arrested, but subsequently have become of enormous size, and continued so almost to the end, as is shown in the accompanying reproduction of a tracing. The pulse-waves were also at this time absolutely consonant with and proportionate to the respiratory movements.

"We believe that our research has demonstrated, first, that the chloride of ethyl is capable of acting as an anæsthetic, but that it is eliminated with extraordinary rapidity, and that its action is extremely fugacious; second, that the anæsthesia which it produces is always accompanied by a fall of the blood-pressure, which is probably at least in part due to the direct depressing effect of the drug upon the heart; third, that the action of the drug upon the circulation is in no way dependent upon its influence upon respiration, although it is not certain that the pronounced depression of the blood-pressure is not a factor in influencing respiratory movement; fourth, that at least in the dog, chloride of ethyl produces at first an increase of the respiratory movement either in rate or amount, or more commonly in each respect, but that finally respiration becomes slow, and at last stops almost abruptly; fifth, that usually, if not always, the cessation of heart-beat and the arrest of respiratory movement occur as nearly simultaneously as may be.

"As the result of the various experiments which we have made with chloride of ethyl, we believe that the fugaciousness of the action of the drug must interfere with its use as a general anæsthetic, and that its depressing effect upon the circulation is too pronounced for it to be a safe anæsthetic. It is most probable that if it should come to be employed in practical medicine as an anæsthetic, there would be a record of sudden deaths through cardiac failure proportionately even more numerous than those caused by chloroform. On the other hand, our research indicates very strongly that the small amount of chloride of ethyl which is used in producing local anæsthesia for dental purposes has practically no effect upon the human system, any of the drug that is absorbed into the system being eliminated in the course of a few minutes."

Pental.

"With pental we have made a few experiments, both by inhalation and injection into the veins. Though the number of these experiments is not great, they seem to us sufficient to show that pental as an anæsthetic acts quickly and fugaciously, but that it will probably be found more dangerous than the chloride of ethyl, and much more dangerous than chloroform. We append a tabular statement of one of the experiments made by inhalation.

EXPERIMENT VII.—Dog, weight 12.345 kilogrammes.

Time. Min.	Time. Sec.	Pressure, Mm.	Pulse per min.	Respiration per min.	Remarks.
0		154	138	30	
0	20	.....	.....	...	*Inhalation* of contents of bottle (10 grammes of drug).
1	20	130	96	63	
2	00	140	96	51	Reflexes weak.
3	10	150	150	60	Inhalation of contents of second bottle.
4	10	100	135	54	Complete anæsthesia.
6	40	150	60	57	Reflexes returned. Great excitement of animal.
11	40	160	.....	...	Inhalation of contents of third bottle.
12	10	90	102	72	
13	10	90	188	75	Complete anæsthesia, but respiration somewhat shallow.
14	10	116	192	69	Reflexes returned. In four minutes later animal had regained complete consciousness, and showed great excitement. Was afterward killed.

"An examination of the record of the experiment just given will show that the production of anæsthesia with pental was each time accompanied by a marked fall of the arterial pressure. Thus, in the first inhalation, the pressure had fallen from 154 to 100 mm., when anæsthesia was complete; whilst during the second anæsthesia the pressure fell from 160 to 90. In each anæsthetization the respiratory rate was increased, although the extent of the respiratory movements most of the time were not distinctly above the normal.

"In no case have we caused death by the inhalation of pental, but the accompanying tracing records the pulse-wave and the respiratory movements under the influence of a lethal dose of pental (two grammes) injected into the jugular vein."

"In our experiments in demonstrating the great effect of pental upon the heart, it is shown that the heart was at once affected much more severely than the respiratory centres, that they failed to recover themselves, and stopped beating before the arrest of respiration; indeed, full, deep inspiration occurred a half-minute after complete arrest of the circulation.

"In conclusion, we are led by our experiments to believe that pental will probably prove to be a dangerous anæsthetic, and if extensively used, will produce death by cardiac arrest. It is probable, also, that the after-effects of pental, in the human being, would be disagreeable; at least we repeatedly noticed in the dog a peculiar wild excitement directly after the anæsthesia from pental had gone off."

"PHENOL AND CAMPHOR.—By various combinations of phenol and camphor, Dr. Shaffer has formed a number of local anæsthetics, which have been found very useful in minor surgery of the ear, throat, nose and teeth.

"The first one is the 'Phenol Camphor,' 'Carbolated Camphor,' 'Phenolated Camphor,' and 'Campho-Phenique.' When common or Japanese camphor and crystallized carbolic acid were mixed together and heated, a colorless liquid resulted, possessing antiseptic and local anæsthetic properties.

"We have employed this agent, on the suggestion of Dr. S. MacCuen Smith, on a dossel of antiseptic cotton, introduced in the auditory meatus, in the second stage of the troublesome form of furunculous inflammation, or when the furuncle has pointed and has discharged, or been opened by a bistoury under careful anæsthetic precautions. By this agent we get rid of the hypertrophy of the canal and relieve pain.

"There are many other forms of these combinations also, When menthol is acted upon by chloral, trichloric-acetic acid and thymol, when heated with camphor, it forms a transparent oily fluid; also menthol with camphor, first described by Dr. S. Scott Bishop, and employed by him in ear and throat dis-

eases. The last of these forms, described by Dr. Shaffer, is as follows:

Mentho-Phenol.

"Mentho-phenol, as its name indicates, is obtained by adding one part of phenol to three parts of menthol, and then melting the mixture. A transparent liquid is obtained, having an aromatic odor and taste. Applied to the tongue, it produces a temporary anæsthesia similar to that of cocaine, although not so lasting as the latter. It is, of course, lighter than water, having a specific gravity of 0.973. It is nearly insoluble in water and glycerine, but it readily dissolves in alcohol, ether, chloroform and most of the light and heavy oils. It dissolves iodine, iodoform and aristol. Water of ammonia, mixed with mentho-phenol, changes it to a dark vinous color in a few days. It is antiseptic, with strong analgesic properties. It may be used preparatory to cauterizing chancroidal sores and curetting necrotic surfaces. As a mouth-wash, it may be used with advantage, two drops being mixed with an ounce of the aqueous menstruum.

"The most admirable results have been obtained by Dr. Edward H. Shaffer, in minor surgery, such as abscesses, using a mentho-phenol mixture (five per cent.) warm, and when the lancet was plunged deeply under the nail, to his surprise the patient uttered no cry nor manifested any demonstrative indications of pain. The patient assured him that the pain had ceased like magic when the finger was immersed in the warm mentho-phenol mixture. The finger was dressed with gauze, rendered antiseptic with two per cent. of mentho-phenol, and healed in a few days.

"In a case of suppurative otitis media et interna, accompanied with great pain and throbbing, an offensive purulent discharge created an eczematous eruption in the vicinity of the outer ear. The frequent syringing of the auditory canal with very warm water, mixed with mentho-phenol, soon checked the suppurative inflammatory process, and resulted in the disappearance of the eczema. In another case, in which a small insect had crawled into the ear of a lady, a warm mixture of two per cent.

of mentho-phenol produced the insect, to the great satisfaction of the patient. Wounds—incised, punctured, lacerated, etc.—will heal kindly when cleansed with warm water, mixed with two per cent. of mentho-phenol. In dental practice, mentho-phenol finds its indications as an anodyne anæsthetic in odontalgia, obtunding the sensitiveness of dentine, and as an antiseptic in alveolar abscess, suppurating pulps of teeth, periodontitis, etc.

"He has used the medicament in pustular acne. The pustules may be opened without causing much pain, after having been first touched with vaseline containing five per cent. of mentho-phenol. Mixed with almond oil or alcohol, in the proportion of two per cent. of the medicament, I have used it as an external application in itching of the skin. I have never used it subcutaneously nor by the mouth. Mentho-phenol, like every other remedy, has its natural limitations of employment. It cannot, for instance, be used in ophthalmological practice on account of the unpleasant burning which follows its use when applied to the conjunctiva."

Resorcin-Camphor.

"This liquid is obtained by heating equal parts of resorcin and camphor. Its indications are the same as those of thymol-camphor. It is superior to the mercurial ointment in the removal of pediculi. My chief object in writing this article was for the purpose of directing the attention of those interested in medical chemistry to the large number of chemical compounds which can be produced when the different camphors are united with the phenols and their congeners. The close chemical relationship of these substances naturally leads one to infer a correspondingly intimate physiological affinity."

Antipyrine as a Local Anæsthetic.

In Vienna it has already been found necessary to forbid the sale of antipyrine except under doctors' prescriptions, as no less than seventeen deaths were attributed to stoppage of the heart's action, owing to overdoses. The freedom with which the prescription of this remedy (antipyrine) has been assumed by

the public has long since been viewed with anxiety by the medical profession, and frequent warnings have already fallen upon deaf ears; and yet it is to be feared that if the epidemic of influenza should spread, many more examples of recklessness will have to be recorded.

Hypodermic injection of antipyrine has been strongly recommended for the relief of pain by See and others. See considers that it rivals morphine in the extent of its action, that it has not the unpleasant after-effects of that drug, and that it does not interfere with nutrition or lead to a "craving." Berdach has lately been experimenting with the drug in this way at Prof. Bamberger's clinic at Vienna. He uses a fifty per cent. solution in distilled water, and has experienced nothing but favorable results. All kinds of painful conditions were so treated, the injection being made at the most painful spot. For a few seconds after administration there is a local pain and burning; but this soon passes off, and is followed by analgesia over an area of more than a centimetre round the point of injection. Frankel and others had previously noted this. The most important point in Berdach's observations is, that the pain is relieved in a few seconds after the injection, the relief lasting for at least six hours. No disagreeable effects, such as vomiting, sweating, rash on the skin, or depression of the heart or pulse were noticed, and in those patients who were febrile the temperature remained uninfluenced. This is too favorable an account, and we cannot indorse these statements, and would advise caution in its use. It is also valuable in chronic catarrh in the form of spray, dissolved in hot water, from 10 to 40 grains to the ounce. At times we commence with solution of cocaine, then followed by antipyrine, or the two combined—2½ parts of cocaine and 8 parts of antipyrine to 100 parts of water —and last, by pure vaseline in pharyngeal irritation involving the nose and Eustachian tubes, with deafness.

CHAPTER XXI.

Local Anæsthetics—Oil of Eucalyptus, Ether, Rhigolene, Methyl and its Chloride, Hydrastine, Homatropine and Ephedrine, Brucine, Apomorphine, Erythrophleine, Caffeine, Helleborine, Canadol, Menthol, Iodoform, Iodol, Bromide of Ethyl, Bromide of Potassium, Carbolic Acid, Quinine, Antifibrin, Tymol, Urethane, Trional and Tritronal, Naphthalene, Sulphonal, Pyoktanin and Trichloracetic, Aristol, Euphorine, Hypnal, Exalgen.

Having given briefly the most important results of the recent observations and experiments with cocaine and eucaine, I now pass to the second part of our subject, the older local anæsthetics.

Oil of Eucalyptus.

This agent is recommended as a local anæsthetic in dental operations and toothache. Apply one drop or more on cotton to the sensitive dentine just before excavating for filling. The vinegar and oil in the form of emulsion is a powerful and useful liniment for neuralgia, etc. The oil has also decided antiperiodic powers, as well as being one of the best stimulating expectorants in acute and chronic bronchitis. From one-half to one drachm a day may be given in divided doses in capsules or mucilage.

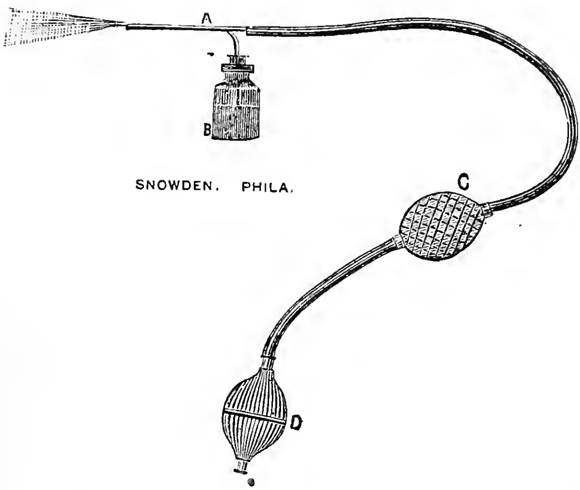
Ether as a Local Anæsthetic.

This apparatus, Plate 55, and the various modifications, are employed for local anæsthesia, and produces so much cold by atomizing the ether and other volatile agents that it freezes the skin and even the deeper tissues. It was first used by Dr. B. W. Richardson, of London. It consists of the elastic bulb D, which, with its valves, serves to force air into the elastic chamber C, which, alternately expanding and contracting, supplies a steady stream of air to the atomizing tubes A, which are of metal, one branch of which dips into the bottle B, containing

the ether, and the inner tube for delivering the ether runs upwards to the extremity of the outer tube. The ether must be directed on the surface, and must be the strongest, therefore free from alcohol and water. When the parts are properly frozen, they become pale, shrunken and tallowy-looking, and, when cut, like frozen fat.

When the rubber bag D is compressed by the hand, the reservoir bulb is filled, and a double current of air is produced; one

PLATE 55.



current descending and pressing upon the ether, forcing it along the inner tube, and the other ascending through the outer tube, and playing upon the column of ether as it passes from the inner tube. The ether which is used in England for producing local anæsthesia is a mixture of amyl hydrate and anhydrous ether; it has a low boiling-point and specific gravity, and is dangerous when inhaled. The best form of ether to employ for local anæsthesia is the anhydrous, which is almost free from alcohol and water, and gives the best results.

Local Anæsthetics.—Rhigolene in Spray.

RHIGOLENE.—This is one of the most volatile of liquids, and is obtained by the distillation of petroleum. Its specific gravity

is 0.625, and it will boil in the hand. It was first introduced by Dr. Bigelow, of Boston.

A superficial layer of the skin has been successfully frozen by rhigolene. Not only on the skin, but Dr. Jarvis and others have used it in inter-nasal surgery by means of an atomizing apparatus, which will freeze the tissues in less than one minute. Cartilage and mucous membrane can, when thus frozen, be deeply and freely divided without much pain or hæmorrhage.

Drs. Edes, Dana and Jacobi had used rhigolene spray with benefit in the treatment of neuralgia; but it has been found objectionable, because of the intense degree of cold produced, and also because it could not be applied to a sufficiently large space.*

In cases requiring extensive operative interference, cocaine has been partially utilized in conjunction with the rhigolene.

At one time rhigolene was considered very explosive; this is not the case unless mixed with air, and brought near to an open light, or the incandescent cautery.

Dr. Richardson, of London, has found rhigolene to dissolve camphor and spermaceti, which solution, applied with cotton and wool, he found an excellent dressing to burns. This same fluid would also dissolve iodine, and was valuable in diseases of the respiratory tract by inhalation. The strength of the iodine solution which he uses is five grains to a fluid ounce of rhigolene.

Methyl.

This is another new local anæsthetic, so stated, but obtained from an old agent, namely, methyl alcohol. This is the alcohol obtained from wood spirit, and much employed in England, but not in this country. The new agent is stated to be neutral, volatile, with an ethereal odor and pungent taste.

The subcutaneous injection of methyl induces more or less anæsthesia, but it is of short duration. (*Vratch*, No. X., 1887, *Bull. Gen. de Therap.*, July 15, 1887, and *Amer. Jour. Med. Sci.*, October, 1887, p. 527.)

* New York Medical Journal, July 31, 1887.

Chloride of Methyl.

Dr. Jacobi has found the chloride of methyl an analgesic or local anæsthetic, which did not affect the general condition of the patient, and that it was invaluable in the treatment of neuralgia, for the immediate relief of severe pain. It was used in the form of spray under high pressure. The objection was the expense of the apparatus and the difficulties of getting the drug (pure).

(See *Med. and Surg. Reporter*, vol. lvii., July 2, 1878, our observations on this drug, and its analogy to chloroform as usually obtained; see also p. 207.)

From his experience in the use of condensed carbolic acid, his conclusions were that, in the absence of chloride of methyl, it was able to take the place of that remedy in sciatica.

Hydrastis Canadensis (Golden Seal) and Hydrastine.

The white alkaloid contained in *Hydrastis canadensis* (Golden Seal). Experiment shows that it is to this alkaloid, rather than its more obtrusive neighbor, berberine (yellow alkaloid), that the valuable properties of Golden Seal are due. Its physiological action, as determined by experiment on the lower animals, is briefly as follows:

"In small doses it elevates and in large doses it depresses the blood-pressure; that in small doses it produces contraction, and in large doses dilatation of the vascular walls; that in the period of elevated blood-pressure it inhibits cardiac action; that in small doses it produces anæmia and in large doses hyperæmia of the alimentary surface; that it induces uterine contractions; that it enhances the irritability of the motor and depresses that of the sensory nerves; and that it exercises its control over all these organs through a central, and not through a peripheral influence."

Experiments on man confirm the preceding. It dilates slightly the pupil of the eye, and as a local anæsthetic has value, though its action is not so marked as that of cocaine or brucine applied locally, or theine injected hypodermically. Hydrastine is most applicable in catarrhal states of the stomach,

bowels, eye, ear, nose and throat, though it is indicated in many other diseased conditions. Amongst the diseases for which it has been found a valuable topical application may be mentioned hyperidosis, seborrhœa, acne, eczema, ulcers, gonorrhœa, certain forms of gleet, various forms of conjunctivitis, and in the ear to arrest or modify irritating catarrhal and purulent discharges. Its effects of contracting the uterus so powerfully may be of special value in obstetrics, and its marked action on the spinal nervous system indicates it as a valuable tonic to this portion of the body. Probably hydrastine possesses much of the therapy internally, as well as externally, of the drug from which it is obtained, such as being indicated in dyspepsia, constipation, hæmorrhoids, jaundice and other functional disorders of the liver, etc.

Dose, $\frac{1}{16}$ to $\frac{1}{4}$ grain.

Mr. I. N. Bredin found the following formula, used as an injection four times daily, gives beneficial results in gonorrhœa and leucorrhœa, when every other treatment, local and internal, failed:

℞	Hydrastin, ...	ʒj.	
	Sol. morphiæ (B. P.), ...	ʒij.	
	Mucil. acaciæ, ad, ...	f℥iv.	M.

SIG.—Use as an injection four times daily.

Care should be taken to distinguish the resinoid of the eclectics, hydrastin, which consists chiefly of hydrochlorate of berberine, from the crystalline alkaloid hydrastine (hydrastina).

Homatropine.

Discovered by Landenburg. It is a derivative of tropeine, which latter is produced by heating tropine gently, in contact with organic acids, and dilute hydrochloric acid. Tropine is a derivative of hyoscyamine, also of atropine. Merck has succeeded in crystallizing it in transparent colorless prisms. The most useful salt has been shown to be the hydrobromate, which is crystallizable and not hygroscopic. Its action is similar to that of atropine, being mydriatic, narcotic, sedative and anæs-

thetic. The dilatation of the pupil takes place very energetically with homatropine, the action beginning in from fifteen to twenty minutes, and reaching its height after from sixty to seventy minutes; while the recovery takes place in a comparatively short time, usually from six to ten hours. It is generally indicated in the same complications as atropine and other alkaloids of this class.

Chlorohydrate of Ephedrine.

Tweedy and Ringer have proved by experimentation that homatropine acts upon the heart in the same way as atropia, but is much milder and safer. Dr. Frommuler prefers homatropine to atropine for checking the night sweats of phthisis. He also found it an immediate and certain antidote to pilocarpin. Dose, $\frac{1}{3}$ to $\frac{1}{4}$ of a grain.

Homatropine has been employed in a large number of cases in this city, of the strength of eight grains to the ounce of distilled water, with the $\frac{1}{10000}$ of bichloride of mercury. The instillations have been made every hour until full dilatation takes place, and with satisfactory results, passing away soon, unless, as will sometimes happen, the druggist substitutes atropine, not having the homatropine on hand.

The chlorohydrate of ephedrine is a new mydriatic alkaloid obtained from *Ephedra vulgaris* by M. Kinnossuke Menra. It should be employed in a solution ten times more concentrated than homatropine, but it is much less costly. It does not paralyze the accommodation for near vision.

Hydrobromate of Homatropine.

($C_{16}H_{21}NO_3HB$. Soluble in ten parts of water.)

A careful study of the action of hydrobromate of homatropine by Risley and Jackson has proved to them that this drug is entirely satisfactory for the correction of anomalies of refraction, and is an efficient and reliable mydriatic.

Brucine.

Dr. Mays, of this city, introduced pure brucine as a local anæsthetic, and kindly furnished us with a solution in oleic

acid. We made a number of careful experiments with it, and found it had some slight anæsthetic properties, but with the objection that when used freely on a mucous membrane or abraded surface it produced some of the symptoms of strychnia poisoning. It is true, it is less powerful, and eliminated more rapidly than strychnia, but it has this one serious objection. The old idea was that the effect of brucine, in producing convulsions, was said to depend on admixture with strychnia, but Dr. L. Brunton found that pure brucine would produce convulsions and death in rabbits when injected subcutaneously.

Apomorphiæ Hydrochloras.

The objection to apomorphia is that it causes very profuse secretions from the mucous membranes. It also acts as a poison on the muscular fibre of the ventricle of the heart, like an acid, when employed internally. Yet there are ophthalmic surgeons of this city who use it with success, applying it every ten or fifteen minutes to the eye, one drop at a time.

Erythrophleine, or Haya.

(The Active Principle of Erythrophlœum Guineense.)

From a most interesting paper, read a month ago (January 11, 1888), before the Medical Society of Berlin, by Dr. Lewein, we extract the following concerning a drug that promises much:

"The hydrochloride of erythrophleine (made by E. Merck, of Darmstadt) is readily soluble in water. A *two per cent.* solution in a dog's eye renders it insensible for from ten *to* twenty-four *hours.* This solution is *much stronger than need be* for anæsthetic uses, as will be seen as we proceed, for Dr. Lewein states that 'solutions of the strength of one-fourth or one-tenth or one-twentieth of one per cent. produce anæsthesia of the cornea and conjunctiva, continuing for from several hours up to two days, and gradually increasing in intensity during that time.' The action is altogether local, and if a solution of it be injected into the *eyelid* of an animal, it becomes so insensible that touch does not induce motion, while the eye itself retains perfectly its sensibility.

"To give an idea of the powerful action of this substance: If we make a solution of the proportion of $\frac{1}{10}$ gramme to 100 grammes of water, *i.e.*, $\frac{1}{10}$ gramme to 2000 drops of water (approximately $\frac{3}{8}$ of a grain to one fluid ounce or a solution of about $\frac{8}{100}$ of one per cent.), and of this inject three full drops into the eye, full anæsthesia is produced (by 0.00015 grammes erythrophleine hydrochloride) (or twenty-three ten-thousandths of a grain). If from 0.0005 grammes to 0.0015 grammes of this solution be injected into a guinea-pig, such an insensibility is produced in the injected part, that one can cut these otherwise so sensitive animals deeply, down to the muscles, without observing any symptom of pain."

According to "Karewski," *Medical Press*, March 4, 1888, complete anæsthesia was never obtained, but its action was much heightened by the local production of anæmia. Its action was not uniform in all cases. Subcutaneous injection of at least $\frac{1}{25}$ of a grain was necessary to produce analgesia.

The after-effects were very disagreeable, amongst them violent pain at the point of insertion, coming on in a few minutes afterwards, and becoming intolerable, lasting several days.

Caffeina—Caffeine.

A crystalline principle occurring in tea and coffee. Various trials of caffeine have not been satisfactory as a powerful local anæsthetic. It is valuable in slight operations, but much inferior to cocaine.

Theine, which chemically is the same as caffeine, has also slight anæsthetic properties. They are both most valuable diuretics. The citrate of caffeine in five-grain doses, alone or in conjunction with antipyrine, is a useful remedy in congestive headaches.

Helleborine.

The helleborus niger contains two active principles, helleborine and helleborin. Both of the substances are glucosides. The first has been employed as a local anæsthetic. Internally they are both narcotics and active cardiac poisons.

Canadol.

This is a volatile product obtained from naptha. Liquid, limpid, very volatile, easily inflammable, benzoine odor. It has been used as a substitute for ether as a local anæsthetic, and is employed by means of Richardson's spray apparatus.

Menthol.

Has been found very useful as a rubefacient, and combined with some hypnotic, it has anæsthetic properties. It is useful combined with cocaine.

Menthol is an oil of peppermint camphor; is employed in diseases of the throat and ear, dissolved in ether or olive oil from ten to fifty per cent. It is a great pain reliever when the crystals are sprinkled on an aconite plaster and slightly incorporated by the aid of heat.

Iodoform. (CHI_3, 392-8.)

Iodoform is employed as a local anæsthetic and antiseptic, as a dressing after operations. Preparation: Mix an alcoholic solution of potash with tincture of iodine, and evaporate it. Character: Small, lemon-yellow, lustrous crystals of the hexagonal system, having a saffron-like and disagreeable odor, very difficult to overcome, and unpleasant iodine-like taste. Not perceptibly soluble in water, soluble in eighty parts of alcohol at 59° F., in five parts of ether, and in chloroform, benzol, benzine, and in the fixed and volatile oils, lard, lanolin or vaseline. Dose, 1–3 grains.

It is given in the form of a pill or in a capsule, or mixed with tragacanth, sugar of milk and glycerine, or better, sugar-coated; by the rectum in the form of a suppository or vaginal capsule. The disagreeable smell may be in part covered by Tonquin bean, coumarin, or roasted coffee in powder.

As an inhalation in phthisis a solution may be used containing 20 grains of iodoform, 20 minims of oil of eucalyptus, or 10 of creasote, ½ fl. oz. rectified spirit, and ½ fl. oz. ether. This is used with an inhaler of horse-hair matting, lined with cotton wool, on the interior of which the solution is dropped. (Dreschfeld.)

As an external application it is dusted over the abraded skin, ulcer, or mucous membrane. An old favorite preparation for topical application is the ethereal solution of iodoform (ʒi. ℥v.) applied with absorbent cotton to the affected parts in the nares, post-pharyngeal space, mouth, fauces, larynx and trachea. The nozzle of the spray-producer is apt to become choked, and must be washed out frequently with pure ether. It may also be applied to the nose in the form of a bougie, containing $\frac{1}{6}$ to $\frac{1}{2}$ grain made with gelatine and glycerine.

Actions: Iodoform destroys bacilli, and is an antiseptic deodorizer and local anæsthetic. It also destroys leucocytes. If given in large doses it weakens the circulation, or if long continued in moderate doses, it has the same action. If absorbed from a large raw surface or employed too freely, it produces muscular rigidity, anæsthesia, sleep followed by sleeplessness, headache, irritability, hallucinations, loss of memory, melancholia, and even death. These disagreeable effects are diminished by bicarbonate of potash, 10-grain doses every hour or two, in water.

It has a most extraordinary power to prevent the development of giant cells, and may thus prevent the growth of morbid tissue, as cancer, etc. After death from iodoform, the heart, liver, kidneys and muscles exhibit fatty degeneration.

Iodoform.

(Cotton Wick.)

Gersung, of Vienna, has found cotton wick impregnated with iodoform an excellent material for tampons in the drainage of wounds whose secretion is moderate ; Bellroth's clinic wick, saturated with tannin and iodoform, is used with excellent results. Its removal is much less painful and inconvenient than that of gauze.—*Centralblatt für Chirurgie*, July 30, 1887.

Deodorized Iodoform and Ointment.

Mr. Louis Genois has advocated the use of the purified naphthaline to mask the odor of the iodoform, as follows:

Purified naphthaline,	. . . . . .	$7\frac{1}{2}$ grains.
Powdered turmeric,	. . . . . .	$1\frac{1}{2}$ grains.
Iodoform,	. . . .	91 grains.

Rub together until thoroughly mixed.

Ointment Iodoform.

Deodorized iodoform (as above),	. . . .	ℨij.	
Oil of almond,	. . . .	ℨiss.	
Lanolin,	. . . .	ℨvss.	M.

We have tried this preparation, but the strong odor of the naphthaline is one objection.

Iodoform in Variola.

Colleville has had excellent results in preventing severe scarring, and lessening pain in variola by the local use of:

Iodoform,	. . . .	1 part.
Vaseline,	. . . .	20 parts.

Although used freely in cases of confluent variola, no ill effects were observed.—*Revue de Therapeutic*, November 5, 1889.

Iodoform Deodorized.

Cantrella, pharmacist, Paris, has found of all the ways devised for hiding the odor of iodoform, the following combination is the best:

Iodoform,	. . . .	gr. xv.
Menthol,	. . . .	gr. $\frac{3}{4}$.
Essence of lavender (of best quality),	. . .	gtt. 1.

In addition, the hands may be washed in water containing a little lavender brandy or essence. Cocaine may be added to the mixture when instant anæsthesia is required, as follows:

Iodoform,	. . . .	gr. xv.
Cocaine,	. . . .	gr. $\frac{3}{8}$.

—*Bulletin General de Therapeutic*, Nov. 15, 1887.

For deodorization of hands or any other part of the body impregnated with iodoform, Doux, in the *Bulletin* of the Pharmaceutical Society of Bordeaux, advises, first, vigorous soaping of the hands, then washing them in water to which is added tincture of iris (blue or white flag), when the odor disappears completely.

Increasing the Antiseptic Powers of Chloroform.

G. de Ruyter (*Arch. f. Kl. Chirurg.*, Bd. xxxv., Hft. 1) states that solutions of iodoform in ether, chloroform and alcohol have greater antiseptic properties than the powdered drug, owing to the production of free iodine. The following solution was found an excellent antiseptic, and much superior to the ethereal one :

Iodoform, ...	1 part.
Ether, ...	2 parts.
Alcohol, ...	8 parts.

The author confesses that outside of the body iodoform has little power over the greater number of disease germs. It has, however, been shown that when in contact with the fluids of the body the iodoform is decomposed, and is then capable of acting on bacteria.

An Antidote for Iodoform.

The *Rep. de Farms* states that Dr. Behring recently gave a twenty per cent. solution of bicarbonate of potassium in a case of severe iodoform poisoning. The best results followed its use, it seeming to act as a direct antidote to iodoform. Fortunately, cases of iodoform poisoning are rare ; so much so, indeed, that they are termed "idiosyncrasies."

Treatment of Diarrhœa by Iodoform and Charcoal.

℞	Iodoform, ...	grs. ix.	
	Ether, ...	℥iiiss.	
	Vegetable charcoal, finely powdered, . .	℥iiss.	
	Glycerin, ...	℥xii.	M.

SIG.—A teaspoonful after each evacuation.

The iodoform must be dissolved in the ether, and the powdered charcoal thoroughly mixed. After the ether has evaporated, the glycerine should be added.

On the Local Use of Iodoform in Ear Diseases and Dental Operations.

The following were the conclusions of our friend, the late Dr. Cassell, after using this agent in the treatment of ear diseases for some years:

"Iodoform is of service alone in cases of ear disease in which there is a lesion of tissue (ulceration), and notably in those of caries of the mastoid, complicated with polypus granulations. After these are removed the local application of iodoform, as a fine, dry powder generally acts capitally, and, I may add, successfully. It is worthy of trial as an internal remedy in those cases of deafness following eye disease, where there are keratitis and scooped (Hutchinson's) teeth, and other outward signs of hereditary syphilis or tuberculosis.

"NERVE PASTE.—A preparation for devitalizing dental pulps, composed as follows: ℞. Iodoform pulv., cocaine hydrochlorat., āā gr. xx.; menthol crust., gr. v.; glycerina, q.s. to make a stiff paste.

"Iodoform has not been much used by the dental practitioner, but I think in it we have a remedy that exactly meets the requirements of some cases. It possesses the alterative properties of iodine, without its caustic qualities; indeed, it is a very soothing application to inflamed and irritated parts. It has been used with the happiest result in the treatment of old abscesses, its alterative and anodyne qualities rendering it just the thing for those cases in which, from the ravages of calculus or from abscess, the socket cells are involved, and that peculiarly annoying neuralgia results, from which the patient finds slow relief. In these cases even the extraction of the tooth does not always bring the immunity sought for some time.

"To apply the paste, take a probe armed with cotton, and take up some of the compound paste, introduce it into the cavity, or under the gum and around the roots.

"It can be introduced into the crown and roots, to relieve

neuralgia, or to cure persistent abscess. In the treatment of antral disease it is regarded as one of the very best remedies. Used as above directed, its effect is very soothing, and it will speedily diffuse itself, and its influence, over the seat of irritation. If some persons should object to the odor, the iodol may be substituted in the place of the iodoform."

Iodoform Gauze Tampons.

Iodoform gauze tampons have been found useful in rectal disease. They are stated to be painless and antiseptic. The mode of preparation of the iodoform gauze is given by Dr. Weir, as follows ("Antiseptics: How Used and How Made," *Med. News*, December 17, 1887):

Pour over five yards of absorbent gauze a mixture of

Iodoform, ...	℥iiiss.
Resin, ...	℥iss.
Alcohol, ...	f℥iv.
Glycerine, ...	f℥vi. M.

The Anti-Bacterial Action of Iodoform.

In an article by I. Amory Jeffries, M.D., of Boston (*Amer. Jour. Med. Sci.*, January, 1887), he states that iodol and salol gave prompt results of anti-bacterial action, but iodoform, he concludes, from numerous experiments, has no direct action as a germicide, a result agreeing with Heyn and Roosing. Looked at from the clinical side, the ultimate object of all medical research, he gives the following rules:

1. Iodoform, not being a germicide, is not a fit substance to use to procure asepsis of instruments, materials or wounds.

2. Iodoform is allowable, in the present state of our pharmacopœia, in inflicted wounds where the true germicides are contraindicated, as by danger of poisoning or impracticability.

3. As has long been known, iodoform has a decided tendency to stop serous oozing, and therefore may be indicated in wounds where the moisture threatens the integrity of the aseptic or antiseptic dressing. Laboratory tests are not always what occurs in the body, and different observers produce different

results. Dr. Robert T. Weir, of New York, with his friend, Dr. Weeks, has published in *Med. News*, December 17, 1887, the following observations on antiseptics: Iodoform in powder only retarded development of germs after twelve hours' exposure. Iodol in powder exerted no effect. Whoever has kept abreast with the current literature will not be surprised at two things: First, that the fact taught us several years ago by Koch has been confirmed by Dr. Weeks, that only solutions or mixtures of the various antiseptics have no value other than is slowly exerted by the fatty matters themselves; and, second, that iodoform—concerning the power of which in germs much has lately been written—exerts its germicide action but slowly. On this point of the value of iodoform in controlling inflammation—ordinary and tuberculous—Dr. Weir says that the clinical experience of surgeons is in favor of its usefulness, and is decidedly opposed to the laboratory deductions. The discussion of this subject, however, has developed the fact that this substance, in dry powder, often contains germs, and that it works best when acted upon and changed by wound secretions. Practically, it is nearly always used in a dampened condition, by him, in the New York Hospital, in conjunction with the moist sublimate gauze. In this combination it is depended upon as a supporter of antiseptics.

Iodol.

"Iodol (CINH) is produced by the action of iodine on pyrol in the presence of caustic potash. It has an acid reaction, is free from the disagreeable odor of iodoform, and contains 88.9 per cent. of iodine. It is a yellowish-brown powder, insoluble in water, slightly soluble in cold alcohol, and readily soluble in oil. According to Mazzoni, it is a more powerful antiseptic than iodoform; it acts as a local anæsthetic and favors granulation; administered internally in doses of two grains, it produces no intestinal disturbance. It may be used in the same way as iodoform.

"I have been using this agent in the place of iodoform. Very many of my patients object to the odor of iodoform; iodol, being odorless, has this great advantage, though its cost at present is

much greater than that of the iodoform. I have found it as useful as iodoform in ear and throat affections. It has been stated that it is not so valuable in intra-uterine affections as iodoform.

"Dr. Assaky, of Bucharest, Roumania, said that wounds unite under iodol by first intention. This union, however, being the result of various and complex conditions attending operation, it is not possible to attribute to iodol alone the absence of suppuration and inflammatory conditions. In wounds which gape and suppurate, iodol is an excellent antiseptic. It rapidly retards suppuration, renders it inodorous, reduces the frequency of dressing and considerably hastens cicatrization. In ulcerating or gangrenous wounds, iodol aids to resist the destructive process, and changes the wound, after a variable time, to a healthy granulating condition. This action of iodol extends itself to hard chancres. In case of soft chancres the result is variable. Sometimes it transforms them into a simple wound with brief delay; at others it is insufficient for this purpose, and it becomes necessary to employ in addition, locally, antiseptic lotions. The same is true with reference to open venereal buboes of the groin. The powdered iodol has this advantage over iodoform, that it is free from odor and is not toxic in its effect.

"Doses of iodol, of from one-sixteenth of a grain to three grains daily produce no functional trouble, even if continued a long time. These doses give marvellous results in tertiary syphilis and in scrofulous affections. In the secondary stage of syphilis, taken internally, it rapidly destroys the syphilitic manifestations. Iodol seems to aid the general nutrition and increase strength and flesh. It is indicated in all cases of specific malnutrition. Iodol is an antipyretic. In acute infectious diseases, such as erysipelas, etc., it causes a rapid fall of temperature.

"(1) Powder of Iodol.—The pure powder may be used; it is readily dusted over a raw surface or insufflated into the throat. Possessing no toxic power, it is of more importance to cover the diseased surface than to measure the dose. For all laryngeal, pharyngeal, post-nasal and oral conditions, this is, perhaps, the most generally useful application.

"(2) A Solution in Alcohol and Glycerine.—This was Mazzoni's original application: Iodol, one part; alcohol, sixteen parts; glycerine, thirty-four parts. This forms a good application by means of the brush, or may be used as a very coarse spray.

"(3) Iodol, One Drachm; Ether, One Ounce.—This forms a clear brown solution, useful for application either by the spray or brush. The ether, quickly evaporating, leaves the powder *in situ*. It is useful for naso-pharyngeal atrophic conditions.

"(4) Iodol, One Drachm; Glycerine, One Drachm; Vaseline, Seven Drachms.—This is a modification of one of Rumbold's sprays. It is a very soothing application for pharyngeal conditions. It requires to be warm before using.

"(5) Iodol Pastilles.—Iodol, one grain; glycerine, one minim; glycogelatine, eighteen grains. These are very useful for chronic pharyngeal conditions, and are much preferable to iodoform pastilles.

"(6) Iodol Bougies, containing half-grain of iodol in each. These are made for me, for use in diseased nasal conditions.

"(7) Iodol Wool, ten per cent., for tampons, etc.

"(8) Iodol Gauze for dressings.

"I have used iodol in a number of cases of laryngeal phthisis with very beneficial results. Adopting Lublinski's method, I have applied it as an insufflation of the pure powder in some cases once daily, in others three times a week.

"Ulcerations in the inter-arytenoid region have cleansed and healed up completely, and the characteristic arytenoid œdema has diminished under its influence. Tuberculous ulcerations of the epiglottis and pharynx have been benefited by it and been arrested, and the distressing pains on deglutition which accompany this condition are much relieved by iodol. In some patients, to whom solid food was entirely interdicted by reason of the pain on swallowing, deglutition has become comparatively easy under daily laryngeal insufflations of iodol. If the iodol is carefully and accurately applied over the ulcerations, it will completely heal them. I have cases under treatment where there was originally extensive laryngeal ulceration, but at present all active mischief is arrested. Iodol remarkably diminishes

the cough of this condition. It is not to be supposed, of course, that insufflations of iodol, or of any other substance, will cure extensive phthisical disease of the larynx, but they will certainly arrest ulceration, relieve pain and cough, and allow the patient comparative comfort. The iodol remains for a long time in contact with an ulcerated surface. Sprays of chloride of zinc (gr. xxx. ad ℥j.) have, in some cases, been combined with the iodol treatment. For ozæna, I find that iodol tampons are effective in arresting the foul smell of nasal caries, or for the true ozænic conditions independent of carious bone.

"As a spray or brush application, it is very beneficial for naso-pharyngeal atrophic catarrhs. For the ordinary forms of pharyngitis, accompanied or not with follicular disease, I find it a very serviceable insufflation, and one which, moreover, is not unpleasant to the patient. The pastilles are also grateful in these conditions. It is important that the application of iodol, as of any other medicament, to the nasal, pharyngeal or laryngeal mucous membrane should be preceded by thorough cleansing of these parts with the alkaline lotion, so as to insure the bringing of the powder into direct contact with the diseased tissue, and not merely to lay it on the surface of the mucus. I have found it produce excellent effect in extensive ulcerations of the inside of the cheek, dusted over the exposed surface twice daily. In cases where there is great pain the addition of one-eighth to one-quarter grain morphine to the iodol insufflated will be found very advantageous.

"To summarize: iodol is odorless or nearly so, tasteless, produces no constitutional effects, contains nearly as much iodine as iodoform, and parts with it more readily; it is antiseptic, anæsthetic, a promoter of granulation and healing; arrests suppuration and deodorizes foul secretions. Possessing thus all the virtues of iodoform, it is surely preferable on account of its pleasant and slight odor and the absence of taste. It does not disturb the stomach as iodoform does."—R. Norris Wolfenden, M.D., in the *Practitioner*.

Iodoform and Iodol.

Is iodol perfectly safe given internally and employed locally? The experiments of Marcus and Pahl (*Maug. Dess. Berlin*,

Ther. Gazette, January 16, 1888) show that when iodol was given in sufficient doses to animals it caused emaciation, albuminous urine, fall of temperature, general loss of muscular power, and finally death from fatty degeneration of the liver, kidney and other tissues. In a case published in the *Ther. Gazette* (see vol. xi., p. 768), iodol caused, when used as a surgical dressing, symptoms of poisoning. Still, it is less poisonous than iodoform, but the post-mortem appearances are the same. It has been found valuable in a number of cases of tubercular laryngitis, throwing the pure powder into the larynx once a week; also in ozæna with good results, alone or combined with creosote and glycerine and boracic acid.

Iodol in Diphtheria.

In order to test the statements of Dr. Mazzoni, Dr. L. L. Stembo, of Vilna, tried ("Proceedings of the Vilna Medical Society," No. V., 1887, p. 114) the local use of iodol in seven cases of diphtheria, two of which were severe. The drug was applied either alone, in powder, or in the form of a solution. (℞. Iodoli., ℈ss.; liq. vini, ʒss.; glycerine, ʒiiiss.) All the patients recovered after treatment lasting from four to six days. The advantages claimed by Dr. Stembo for iodol are its complete harmlessness, its freedom from unpleasant smell or taste, the painlessness of its application, and the absence of any untoward or secondary effects, such as loss of appetite, nausea, vomiting, etc.—*British Medical Journal*, April 9, 1888.

Trousseau has found the following formula useful:

For an ointment:

Vaseline, ...	℥ijss.
Iodol, ...	gr. 30 to 60.

In solution:

Iodol, ...	3 parts.
Alcohol, ...	35 parts.
Glycerine, ...	62 parts.

In disease of the ducts, as the lachrymal, etc., the following was found useful:

Liquid vaseline, ...	ℨviiss.
Iodol, ...	gr. xlv.

(*Revue Gen. de Clin. et Ther.*, December 29, 1887 ; *Med. News*, January 28, 1888.)

Mazzoni, who first proposed the use of iodol in practical medicine, employed a solution composed of iodol, one part; alcohol, sixteen parts; and glycerine, thirty-four parts.

The dose of iodol is from two to three grains a day, but both Pick and Assaky have given as high as thirty grains a day without injury. Pick asserts that iodol is absorbed much less freely than iodoform, requiring from twelve to eighteen hours for the full elimination of the iodine in the urine when tested by a solution of starch.

Dr. Harlan, of Chicago, uses iodol in combination with pure terebene, as a topical application to lacerated edges of the gums after the removal of necrosed bone. It has been also found beneficial in the treatment of pyorrhœa alveolus. Combined with oleum gaultheriæ, it forms an excellent antiseptic in destroying the odors in the cavities of diseased teeth, and controlling pain. Iodol and the other substitutes for iodoform have not, as yet, taken its place; it is still employed most extensively both in surgery and general medicine with success.

Bromide of Ethyl as a Local Anæsthetic.

The bromide of ethyl has advantages as a local anæsthetic, a pleasant odor, not inflammable, and has been used in France and this country with good results (see pp. 227 to 238). The ordinary atomizer produces a satisfactory spray with the bromide of ethyl, ether and rhigolene.

Bromide of Potassium as a Local Anæsthetic for the Genito-Urinary Apparatus.

Bromide of potassium has long been used as a local application to the throat and larynx to diminish sensibility. Acting upon this suggestion, J. Kijanizyer (St. Petersburg *Med. Wochenschr.*, No. 51, 1879—*Medical Record*) applies it in a similar manner and with similar effects to the genito-urinary

apparatus. He injects a solution of salt into the urethra, when the latter is the seat of painful, acute or chronic inflammation in strictures, and in cases of frequent pollutions. In urethritis, he says, that the pain, redness and tumefaction of the mucous membrane decreased rapidly, the discharge diminished, and soon disappeared entirely with the aid of mild astringents. In a case of stricture, with chronic urethritis and painful micturition, where the urethra was extremely sensitive, and the severe pain prevented the introduction of bougies, in spite of the use of cannabis indica and belladonna salve, a bougie was introduced with scarcely any pain after the use of bromide of potassium injections for seven days. Kijanizyer uses eight grammes of potassium bromide dissolved in 180 grammes of water. Four grammes of the fluid are injected two or three times a day, and the fluid retained in the urethra a few minutes. From his observations he concludes that the injections are of decided use, in all cases where the indication is to diminish sensibility in the urethra and neck of the bladder; in the treatment of strictures with bougies, in inflammations of the urethra and their complications; in chordee, dysuria, neurosis, etc., and for pollutions depending upon peripheral causes. He also recommends the local use of the salt, as indicated in catarrh of the bladder and of its neck, in increased sensibility of the latter, and for cystic calculi and the like. He considers the effects to be due to the diminished irritation and lessened quantity of blood in the inflamed tissue.

Ethyl Iodide.

This agent has been found useful as a local anæsthetic, and anti-spasmodic in hay-fever and cold in the head. It is most effectively applied by means of glass capsules broken in a handkerchief, and then inhaled from it, covering the face. Another method is by means of a half-filled glass bottle, which is inclosed in the hand, the heat vaporizing the liquid.

Chloral and Camphor as a Local Anæsthetic.

Equal parts of chloral and camphor were recommended years ago by Dr. Fordyce Barker to stop the secretion of milk, and

now we note from the *Canada Med. and Surg. Jour.*, March, 1885, that before the Medico-Chirurgical Society of Montreal, Dr. Lapthorn Smith read a paper on the use of a mixture of about equal parts of chloral hydrate and camphor as a local anæsthetic. He stated that when placed in the solid form together in a bottle they soon produced a clear, thick liquid, which, when applied on a piece of lint, covered with oil-silk, to a painful surface, complete analgesia resulted. He reported three cases in which he tried it with good success. The first was a whitlow of the finger, which the patient refused to have opened. Shortly after applying it the pain disappeared, and three days later it was lanced, and the pus let out without the patient, a young lady, experiencing any pain whatever. The second case was a very painful bubo, which completely disabled the patient, a gentleman, from doing his work. The mixture of chloral hydrate and camphor was applied frequently on a piece of lint, with the result that a few hours after the first application he was so much relieved that he returned to his duties next day, and fluctuation becoming evident a few days later, it was opened, the operation causing only about a quarter of the usual amount of pain. The third case was an operation for the removal of a large sebaceous cyst of the face, which was accomplished after the frequent application of the local anæsthetic for several hours previously by means of a brush. The incision in the skin was almost painless, but it produced no effect upon the deeper structures to which the cyst was firmly adherent. The action of the anæsthetic is much less marked on healthy than on inflamed and painful skin.

Piper Methysticum and the Cocaine Molecule.

Filehn remarks (*Berl. Klin. Woch.*, vii., 1887), that for a time cocaine seemed to stand alone in its local anæsthetic action. Then a similar property was found to belong to the resin from *piper methysticum* (Kava). All the ordinary alkaloids have been tested in reference to this point by Bergmeester and E. Ludwig, with negative results. Searching after a substitute, Filehn directed his attention to the chemical constitution of the cocaine molecule. Just as atropine can be split up into and re-

constituted from tropic and acid tropin, so cocaine can be resolved by heat into benzoic acid, methyl alcohol and ecgonine.

Carbolic Acid.

CARBOLIC ACID (*carbo* and *oleum* "oil").—Carbolic acid, impure (*acidum carbolicum*), a liquid obtained from coal-tar oil by treating it first with an alkali, then with an acid, and finally distilling it. It is of a brownish shade, becoming reddish brown on exposure. It consists of carbolic acid and cresylic acid, with impurities derived from the coal-tar.

This form is only used externally, or for disinfecting purposes, and, at the iron works, mixed with oil for relieving burns.

PURE CARBOLIC ACID (*acidum carbolicum purificatum*).—When pure, and while it is in crystals or liquid, it is also termed phenic acid, or phenol. Its odor and taste is like creosote, fusible at from 93 to 104, forming an oily liquid, soluble in from 20 to 33 parts of water, and in alcohol, ether, glycerine, and the essential oils. Carbolic acid, if applied to the skin, produces pain and local anæsthesia, so that the actual cautery and other irritating substances can be applied, or incision made with comparative impunity. In the form of slightly carbolized oil, it is most valuable in burns over a large area of skin, yet care must be observed for fear of absorption, if there is much loss of the skin. It is also used in treating surgical diseases by hypodermic injections, as hydrocele and hæmorrhoids. Carbolic acid prevents or corrects putrefaction in cases of purulent infection, dissecting wounds, hospital gangrene, and parasitical diseases of the skin, as scabies, prurigo, thrush. Internally it may be given in doses of from ½ grain to 2 grains, in a tablespoonful of some bland liquid, every hour, in cases of yeasty vomiting, flatulence, dependent on fermentation in undigested food. Its salts, as the carbolate of soda, of potash, zinc, have been used externally for local application and for disinfecting purposes; also in various aqueous, alcoholic and ethereal solutions, and in the form of liniment and ointments.

It has been ascertained that if animals, to whom carbolic acid had been previously administered, are treated by soda sul-

phate, a harmless compound of phenol and sulphuric acid is formed. Thus it has been found that the symptoms of carbolic acid poisoning are relieved by the free use of this agent. If this, or even the common Glauber salt, is given when the urine becomes dark-colored, it will arrest the toxic phenomena from slow poisoning. In these sudden cases, when the carbolic acid is swallowed in such large quantities, it has been advised to resort to zinc sulphate, sulphate of magnesia, Epsom salts, or any sulphate. After the evacuation of the stomach, the free use of lime-water and olive or linseed oil is useful to soothe the burnt mucous membrane, and when this is not at hand resort to flour starch, eggs or milk with warm water. While a resident physician at the Philadelphia Hospital a fatal case of poisoning took place from swallowing the ordinary liquid acid, which is of a brown color, resembling brandy; the individual mistaking it for that agent, swallowed it. Collapse followed, and death was almost immediate. Several similar cases have occurred since. The seventh case occurred at Liverpool quite recently, the acid being mistaken for spirits, as reported in a Glasgow newspaper while we were on a visit to that city. In the first case which we had the opportunity of seeing a post-mortem was made, and the tissues, from the throat to the rectum, were of a brown color, and changed to a leather-like consistency, while the urine and other secretions were black.

Carbolic acid has produced poisoning both by its local application and by being swallowed. Children and delicate women have been the sufferers from its free local application. It produces a species of intoxication. The symptoms are, in the case of adults, nausea, vomiting and headache; but in children the symptoms are more severe, the temperature falling below normal, the pulse being extremely weak, and the body covered with a cold sweat.

Fatality in a Belfast Hospital.—A patient in Belfast Hospital, named James Jeffers, was accidentally poisoned in that institution, through taking a draught of carbolic acid, which the nurse in the ward in which he was located gave him in mistake for a black draught. After drinking a portion of the stuff, Jeffers remarked, "You have given me the wrong

medicine,'' and fell back insensible. The nurse having discovered the mistake, by testing the liquid, rushed wildly for the house physician, who was promptly in attendance. Antidotes were administered, but the man died an hour afterwards. Miss Torrens, who was taken seriously ill shortly after tasting the poison, was placed under arrest. She was not aware of the death of the patient, and the doctors considered it would be injudicious to inform her of the fact. The affair created quite a sensation in Belfast, where Miss Torrens' friends move in the best society.

ANOTHER.—Another death from carbolic acid poisoning—the eighth in a few weeks—occurred at Liverpool, a woman drinking the poison in mistake, as usual, for spirits.

Quinine an Antipyretic and Anæsthetic.

The first and best known of the agents is the active principle of cinchona, or quinia, and its various salts, but chiefly the sulphate, which is now so extensively employed. This valuable medical agent, some twenty years ago, was most employed by Fenner, of New Orleans, and in enormous doses as a sedative in all kinds of fever ; but it was found that in many instances it depressed the nervous system and acted most injuriously upon the patient—so that at the present day it is no longer employed in such poisonous doses. Soon after the Germans took up this same drug and described it as an antipyretic, and with it endeavored to reduce the temperature of all fevers, especially that of typhoid. In thus endeavoring to cure the disease by the simple reduction of temperature, they did not effect a cure, but frequently the immense doses of quinine acted upon the nervous system and as an anæsthetic, and caused the death of the patient.

At the present day it is resorted to chiefly as an antiseptic to combat or destroy the various forms of bacteria, or micrococci, and diseases of a remittent or intermittent type. To obviate its injurious effects upon the nervous system it should be combined with the bromides or hydrobromic acid, or extract of ergot.

Local Anæsthetics, Analgesics and Hypnotics.

"*Thymol*, the product of the fractional distillation of the volatile oil of thyme, obtained from the plant thymus vulgaris, has long been used as a substitute for carbolic acid, in its varied applications, with the great advantage of having a less disagreeable odor, and causing no pain, as it is not irritating.

"It has recently found a new use in the treatment of chyluria dependent upon filaria in the blood. As a remedy for this affection has long been sought, the favorable report of Surgeon-Major E. Lawrie, of Hyderabad, of a cure of two cases is worth noting. The important practical point noticed was that thymol destroyed the organisms present in the system. Reasoning *a priori*, Dr. Lawrie tried it extensively in diseases such as leprosy, phthisis and gonorrhœa, but without success. His conclusions then are that either thymol, acting evidently as a fatal poison to the filaria, is not a poison to the bacillus, which seemed to him very unlikely, or else the bacilli are not the cause of the diseases above mentioned. Other cases are now necessary to corroborate Dr. Lawrie's good results." (Dr. Squibb's *Ephemeris*, vol. iii., No. 6, p. 1311.)

Dr. Hartmann (*Deutsche Med. Wochenschrift*) has employed thymol in toothache from cavities, in place of arsenious acid. He fills the cavity of the tooth with a tuft of cotton on which thymol has been sprinkled. It does not irritate the mucous membrane of the mouth much, and it is easily removed by rinsing the mouth with water. If a rapid action is desired let the patient rinse the mouth often with warm water, in order to facilitate the solution of the drug. It never increases the pain at first, as arsenic does, and is not poisonous.—*Lancet-Clinic.*

"SULPHONAL is one of the usually safe (but uncertain) hypnotics which has had very wide use, and has largely increased during the past year. Two of its properties of great merit are its odorlessness and almost tastelessness. (The usual dose is from ten to fifteen grains suspended in hot water.) Its effect has been noticed to last over to a second and third night; and if this peculiarity is noted, it has its evident advantages as well as disadvantages. Italian observers have mentioned favorable

results in diabetes. It diminishes the quantity of sugar, the polyuria, and the thirst. They also have noticed its good effects in either greatly diminishing, or entirely suppressing, the night-sweats in phthisis. Dr. D. D. Stewart, of Philadelphia, recommends it to be taken thoroughly dissolved in as hot an aqueous solution as agreeable. Sleep is then induced very soon after taking, and thus is avoided the usual delay of an hour or more before the effect is ordinarily produced. Dr. W. H. Gilbert, of Baden-Baden, reports danger from its popular and steady use. It is surely bad practice to leave the matter in the patient's hands to the extent of directing him to take a certain dose whenever he cannot sleep, as is apparently the practice with some. There are evidences now on record of the habit being established approaching that of the morphine habit. Fatal cases also have been reported during the past year. For such an effective and widely used hypnotic, then, the conclusion should be to use caution."—*Ephemeris*, vol. iii., No. 6, p. 1310.

Sulphonal (Di-Ethyl-Sulphon-Di-Methyl-Methane) continues to be a very prominent agent in the practitioner's hands, although caution is urged and generally exercised.

"Occasionally an eruption over the body follows its use. After a time the urine is found to be of a dark color, which a microscopical and clinical examination proves to be caused by the presence of hæmatoporphyrin, and in some cases large quantities of indican. Experience with this hypnotic teaches us to be very cautious in its administration, to watch closely the effects of the first doses in a patient who has not previously taken it, and always to discontinue its use when the urine gets dark."

Dr. Edmund Andrews, of Chicago, Ill., Professor of Clinical Surgery in the Northwestern Medical School, writes as follows:

"I found, some years ago, that it had a singular antispasmodic quality, and, in consequence of my brief writings and personal statements on that point, it is considerably used in Illinois for that effect.

"In the painful muscular spasms after fractures of the thigh and of some other bones, its effects are surprising in

effectually suppressing the spasms without necessarily inducing sleep. Opiates will do as long as the patient keeps awake, but the moment he drops asleep he is liable to be aroused by the spasms. Sulphonal suppresses them totally by night or day, without any reference to whether the patient is asleep or awake.

"Some healthy men are troubled by cramps in the limbs at night. Sulphonal taken occasionally—sometimes only once a week—prevents them. The effect seems to be very prolonged.

"Some cases of persistent hiccough are stopped by it.

"Some surgeons use it to arrest nocturnal emission of semen with striking effect, the action seeming to be by arresting the nocturnal spasms of the ejaculatory muscular fibres that expel the semen.

"I do not know that any one has tried it in epilepsy or tetanus.

"Its hypnotic and anodyne powers are feeble.

"I have not seen it produce any of the alarming symptoms often described when given in 10- or 15-grain doses for cramps once in a day or two, or in 8-grain doses for nocturnal emissions given two or three times a day."

Mr. J. A. Shaw-Mackenzie, M.R.C.S., of London, England, recommends this agent in railway and sea sickness. He reports as follows :*

"Inquiry elicits the fact that there are many who suffer from railway sickness. I am not aware that direct attention has been given to this special cause of megrim ; I am satisfied, however, that the inconvenience is real, and that there are many who are more or less affected by a long journey, and in whom a railway journey of two hours produces as much dread and misery as a sea passage. I venture to draw attention to the value of sulphonal in these cases, and to suggest its further and more extended trial in both railway and sea journeys. In children, train sickness is common, while in adults railway megrim varies

* London Lancet, vol. i., 1895, p. 1434; Ephemeris, vol. iv., No. 1306, p. 1728.

from undue fatigue and inability to sleep the same night to intense headache, sickness and prostration coming on after some two hours in the train. The dose of sulphonal would vary, of course, according to the severity of the symptoms and the length of the journey. In my own case I find that 10 to 15 grains are sufficient for the day journey to Edinburgh, while 20 to 30 grains in divided doses are necessary for the night and day journey to the north of Scotland."

"*Sulphonal.*—This is a hypnotic, valuable in insanity when sleep is required, but there is danger from it in doses of 3 to 4 grammes, and it then becomes a poison. From the deep sleep which it produces, if weak from loss of blood, the patient is apt not to recover. At other times it causes alarming symptoms in the intellectual functions, disorder of the motor system and digestive tract. The dose is from 5 to 15 grains one to three hours before going to bed; better taken with hot fluid."

"PYOKTANIN (methyl-violet) is the newly adopted trade name given to one of the aniline dyes long used for staining bacilli and micro-organisms; it is now believed to have a destructive action on these organisms, and it has been put forth as a new antiseptic and bactericide. There is another form called the yellow. Each is used for special purposes. The former seems now to be preferred in surgical operations generally, and the latter in ophthalmological in particular. Its pus-destroying property, from which it derives its name, is apparently well established at this time, but it has not shown uniformly good results otherwise. However, there are observers now who claim that it has little effect, if any, on suppuration, and the staining of the hands and clothes which accompany its use is strongly against it. This latter objection, however, has been met somewhat by the suggestion that these stains may be removed by soap-lather well rubbed in, and washing or brushing off with alcohol. It has been employed in the treatment of cystitis with some favorable results; but in general urethral injections, where much good may follow, Mr. F. F. Burghard, of King's College hospital, claims that too strong solutions are recommended. He advises beginning with a solution not stronger than 1 to 3000, and gradually increasing up to 1 to

1500, otherwise irritation and scalding on micturition occur. On open wounds and ulcers the powder is simply dusted on with good effect, and where they have become septic this agent is more efficacious than any other antiseptic. Remarkable success is reported from abroad from its use on malignant growths; and even cancer has been experimented upon, both here and abroad, with the result of ameliorating the suffering and of acting as an effective deodorizer. In the various affections of the eye very diverse reports are on record, both in this country and abroad. In general, the majority acknowledge that some good effects follow its use, but it has not yet arrived at that surpassing value at which its introducer would figure it."—*Ephemeris*, vol. iii., No. 6, p. 1306.

"ACID TRICHLORACETIC offers us another great agent for detecting albumin in urine. It is one of the newer tests, which bids fair to remain with us. It has been used considerably since it was first brought forward, and with success. Insurance examiners are the loudest in praising it. It may be used in the form of a saturated solution, or a crystal of the acid may be dropped in the suspected urine. The turbid line, which forms immediately at the junction of the liquids, is to be distinguished from that formed by urates by the rapidity of formation of the former.

"This acid has also been found effectual as a caustic and astringent. In throat and nose affections its effect is much more local than some of the other caustics. It is readily soluble in water, and deliquesces easily. Out of 140 cases treated by one practitioner, 87 needed but one application. Dr. J. W. Gleitzmann, of this association, has met with very favorable results, and summarizes as follows: '1. Trichloracetic acid compares favorably with other caustics in hypertrophic conditions of the throat and nose, and is a valuable addition to the remedies now in use. 2. In the greatest majority of cases it is sufficient to produce the desired reduction of tissue, although it does not supersede the galvano-cautery. 3. It can be applied with safety to the larynx without any evil consequences. 4. Its chief advantage in nasal affections is the dryness of its eschar, which prevents unpleasant sequelæ, and makes after-treatment unnecessary.'"—*Ephemeris*, vol. iii., No. 6, p. 1285.

"ARISTOL is one of the new antiseptics brought forth as a substitute for iodoform. It is a reddish-brown powder made by treating a strongly alkaline solution of thymol with iodine. It gradually becomes paler in color, due to the iodine given off from exposure to sunlight and to heat. It therefore should be kept from an undue amount of light or heat. It has the disadvantage in some respects of being insoluble in water. Owing to its unstable nature, the excipients which may be employed are limited. It is used mostly in the powdered form, but its use with olive oil, collodion and the ointments in general is rapidly on the increase. For the two previous years it has been mostly known by the name of 'annidalin,' but recently, and since the inauguration of new modes of preparation, it has been urged forward with renewed vigor under its present name.

"From recent investigation it appears that its efficiency is largely due to its instability, and any attempt to render it free from its property of slowly giving off iodine renders it comparatively inert. It has been suggested that this very fact may account for some of the failures which have been reported by some investigators.

"Aristol at the present time has universal testimony as to its usefulness in medicine. Some go so far as to claim that it is one of the most important additions to our materia medica in recent years. Its antiseptic power is very pronounced. It has a slight, but not unpleasant, odor. When dusted on open wounds or ulcers it is not irritant, and promotes rapid cicatrization. It has no toxic effects, as iodine cannot be found in the urine after using in any of its forms of application: It is, therefore, a safe remedy to leave in the hands of a patient, as experience has now proved. None of the iodoform substitutes have as large a proportion of iodine as iodoform itself, aristol having less than one."

"RECENT HYPNOTICS AND ANALGESICS.—Urethane—ethyl carbonate. A decided antagonist to strychnine. Also a hypnotic in doses of 30 to 60 grains; but it was noticed that a rapid tolerance of the drug took place, and is therefore unreliable. *Chloral Hydrate.*—This is not a certain hypnotic, yet in doses

of 30 to 45 grains it has been found useful. Occasionally, headache, giddiness and nausea follow its administration, with diminished tension and frequency of pulse.

"TRIONAL AND TETRONAL.—Trional and tetronal contain three and four ethyl groups, and sulphonal only contains two. As a hypnotic, tetronal was, in fourteen cases, superior to sulphonal, in six cases equal, and in four inferior. The dose is the same. In a more recent report tetronal is said to have all the disadvantages of sulphonal without its power, its action being more sedative than hypnotic. *Euphorine.*—Euphorine is phenyl urethan, derived from aniline—white crystalline powder. It is an antiseptic. Dose, from 15 to 20 grains in twenty-four hours; can be taken without bad results. In a few cases euphorine acted well as an analgesic, but, on the whole, the success must be considered small. According to 'Sansoric,' in chronic ulcers and ophthalmia, the powder proved itself a better antiseptic than any other which the author had tried.

"*Hypnal.*—By heating antipyrine with chloral hydrate a crystalline compound is produced which is termed hypnal, and partakes in a marked degree of the properties of both. Dose, 15 grains. It was found to produce sleep with anodyne effect.

"*Exalgin.*—Methylacetanilid; a benzine derivative allied to phenacetin. Dose, ½ grain in facial neuralgia, given in rectified spirits. It was found unsuitable as an antipyretic because, in full doses, it is apt to produce untoward symptoms."—*Ephemeris*, vol. iii., pp. 1283–1288.

Naphthaline.

Naphthaline (CH) is the product of the distillation of coal-tar, of which it posseses the disagreeable odor. It should be carefully used on account of its irritant effects on the renal tissues, and the peculiar modifications in the nutrition of the eye.

Naphthaline has been found useful in flatulent dyspepsia in combination with a small portion of morphia.

Naphthaline has been found one of the best agents for expelling tænia and ascarides. The dose for an adult is 15 grains

when the stomach is empty (in capsules), followed immediately by two tablespoonfuls of castor oil. Children may take 4 to 8 grains, and at the same time a tablespoonful of castor oil. Prior to taking the dose the patient should eat freely of salad and green food.

Guaiacol (Monomethyl-Catechol; Liquid Methyl Ether of Protocatechin).

Obtained from beech-wood creosote by fractional distillation—$C_7H_8O_2 = C_6H_4(OH)OCH_3$—colorless, limpid, oily liquid; aromatic odor. Specific gravity, 1.33 at 15° C. Boils, 201–207° C. Antiseptic, antipyretic, analgesic. Tasteless, insoluble in water, slightly soluble in alcohol and ether, sparingly soluble in glycerine and fixed oils. It may be given in capsules, wine or oil. Dose, five drops daily. Valuable local remedy in lupus and other forms of external surgical tuberculoses. It has been found by Dr. William James Morton that guaiacol restrains the action of cocaine to local territory and prevents its toxic action. (See his article, p. 380, on Guaiacol-Cocaine Cataphoresis.)

TROPACOCAINE.—This alkaloid was obtained from the narrow-leaved coca plant of Java. It is in the form of an oily liquid, which solidifies in radiating crystals, and is soluble in chloroform, ether and benzine. Dr. Arthur P. Chadbourne has found its action similar to cocaine, and only half as toxic as cocaine. In lower animals, in full doses (dose not stated), loss of co-ordination, followed by violent convulsions, disturbance of respiration, coma and death by centric asphyxia. Tropacocaine has been used as a local anæsthetic in the eye, it is asserted, with good results. This has not been confirmed. It acts more quickly than cocaine. It is not a good mydriatic.

BENZOL (benzoin) C_6H_6. A hydrocarbon formed by the dry distillation of organic substances, but chiefly derived from coal-tar. It is inflammable and very volatile, and is an excellent solvent for grease. It acts as a local anæsthetic on epizoa. Its vapor is used in whooping-cough.

"CHLORALAMID (chloral-formamide) is the new hypnotic obtained by the combination of chloral and the colorless, oily,

liquid formamide—an organic compound allied to urea. Our foreign brethren are very enthusiastic over their results with it as a decided rival to chloral and sulphonal. Its best effects are produced in cases of idiopathic insomnia, cases where the insomnia is not due to either extreme pain or excitement. Although it may succeed in some cases in overcoming slight pains, it cannot be classed as an anodyne. It induces a natural and refreshing sleep, and, as a rule, is not followed by headache on waking the following morning. A sense of well-being is the result of the rest it affords. It is thought by some to be a deeper sleep than that produced by chloral. There have been some failures to produce sleep with it, but the per cent. of such cases is small. Some Parisian and German observers claim that its action is exactly the same as chloral hydrate, if allowance be made for the smaller proportion of chloral anhydride in the chloralamid. It was supposed that it acted by decomposing in the circulation, liberating chloral; but there does not occur with it the marked depression so characteristic of chloral. In the majority of cases it works well, but in a small proportion there are unusual effects, not, however, in greater proportion than with morphia or chloral. There are no apparent cumulative effects, and no craving for it is noticed, although it may be given nearly every twenty-four hours for several weeks. Of late some success has been met in cases of epilepsy; but the most satisfactory results have been obtained in senile insomnia, pulmonary diseases and hysteria. It appears to possess the very happy property of counteracting the desire to micturate at night in senile cases. It occurs in colorless crystals, with a mild, slightly bitter taste, and without odor. It is soluble in about ten parts of cold water, and one should be cautious not to dissolve it in warm water, nor to heat the solution after it is made, as it very rapidly decomposes. Its use in this country is rapidly spreading."—*Ephemeris*, vol. iii., p. 1292.

PART SEVENTH.

CHAPTER XXII.

Anæsthesia and Anæsthetics.

A Supplement for the Student to Commit to Memory.

Anæsthesia—the word is derived from the Greek *αναισθησια*, want of feeling, or condition of insensibility, or loss of feeling due to a variety of pathological conditions of the brain centres. The origin of the phrase "artificial anæsthesia" is due to Oliver Wendell Holmes. Anæsthetic, not to feel, a substance that produces insensibility to feeling of pain, and causes muscular relaxation. Anæsthetics act in various ways, as general, partial and local.

The first systemic anæsthetic is *alcohol.* It is a cardiac stimulant and anæsthetic. It is obtained by the distillation of fermented grain, as "Spiritus Frumenti," or whiskey, but, to be pure, alcohol must test not less than forty per cent. Absolute alcohol is purified by redistillation and bone-black filtration. The symbol of alcohol is ($C_2H_5HO_4$), and contains but nine per cent., by weight, of water.

Ether (made by the action of sulphuric acid on alcohol) is the first and most important; it is a stimulating anæsthetic. Anæsthesia by ether is divisible into two stages. The first is one of excitement, and the second stage is evinced when the conjunctiva is insensible to the touch of the finger, and muscular relaxation is complete, with slightly stertorous breathing. During the second stage there is complete loss of consciousness, with perfect relaxation, and when the arm is lifted it falls at

once. The respiration is slow and regular. If this anæsthetic stage is forced, the stertorous breathing is increased, and there is partial paralysis of the muscles of the palate, in which event it is a good rule to temporarily withdraw the anæsthetic agent.

Ether, one of the most important of stimulating anæsthetics (U. S. P.). Specific gravity, 0.725–0.728 = 64°. Boils at 37° C. Ethyl oxide, ethylic or sulphuric ether, should contain ninety-six per cent. ether, four per cent. alcohol, traces of water, $C_4H_{10}O$. Discovered in 1540 by Valerius Cordus, who gave it the name of oleum vitrioli dulce. Frobenus changed the name to ether in the year 1730. Its anæsthetic properties were first suggested by Dr. Jackson, of Boston, to W. T. G. Morton, a dentist, who employed it under the name of "Lethion" for extracting teeth; and the first successful demonstration in general surgery was made by him in the Massachusetts General Hospital, October 16, 1846, when Dr. John C. Warren removed a tumor without any indication of pain.

Ether is produced by acting upon strong alcohol* with sulphuric acid, and heating the mixture to 280°–300° F. This compound undergoes double decomposition, ethyl sulphuric acid and water being first liberated, the ethyl sulphuric acid afterwards combining with a molecule of alcohol to form ethyl ether and sulphuric acid, thus:

Reaction, $C_2H_5OH + H_2SO_4 = SO_2OHOC_2H_5 + H_2O$.
Then, $C_2H_5OH + SO_2OHOC_2H_5 = (C_2H_5)_2O + H_2SO_4$.
Formula, $(C_2H_5)_2O$ or $C_4H_{10}O$.

The ether is purified by passing over fused chloride of calcium, which removes the alcohol, and is then rectified by distillation. The vapor is very inflammable and sinks, by its density, to the floor. There are sold three kinds of ether—commercial ether, unfitted for anæsthesia, purified ether, and absolute ether.

ADMINISTRATION.—Ether as an anæsthetic should be given cautiously with great gentleness by dropping from a bottle upon a folded napkin or by means of Allis' inhaler.

* Ethyl hydrate, absolute alcohol ($C_{20}H_5OH$) of good quality should not contain more than one per cent. of water.

Chloroform.

Chloroform was discovered as *chloric ether* by Guthrie, in America, and by Soubeiran, in France, in 1831, who made it by the action of chloride of lime on alcohol. In 1832 chloroform was rediscovered (chemical process) by Liebig. By him it was produced as follows: Methyl chloride and chlorine in vapor $CH_3CH + 2Cl_2 = 2HCl \times CHCl_3$. By this method it was very impure. Its impurities, methylic compounds, were very common, and can be detected by the addition of a few drops of sulphuric acid. If impure, this acid will blacken the liquid (chloroform).

The ordinary process of manufacture is by the action of bleaching powder upon alcohol, and the chief impurities are free chlorine gas and hydrochloric acid.

The cheaper process for the manufacture of chloroform is termed the *acetone* process; but this "acetone," which is obtained from various sources, is not always pure. The proper agent to be employed is alcohol. Many of the fatalities are, no doubt, due to the use of this cheap variety of chloroform.

A very pure Chloroform is now made from Chloral Hydrate.

Added Impurities.—Alcohol or ether. Chloroform boils at 60° C.; sp. gr. 1. A temperature of 96° vaporizes chloroform if held in the hand. It is not inflammable, but near a flame of gas decomposes, separating into poisonous vapors. Chloroform should be kept in tin or dark amber-colored bottles, and in the dark.

Specific gravity 149° at 15° C. Boils at 60° C. Comp. HCl_3.

A form of stimulating anæsthetic mixture is composed of alcohol, ether and chloroform, or nitrous oxide and oxygen. Chloroform is a depressing anæsthetic. The principal general or systemic anæsthetics employed are alcohol, nitrogen monoxide or nitrous oxide, ether or ethyl oxide (C_4H_5O) $(C_2H_5)O$, chloroform, methyl chloride, terchloride of formyl, bromide of ethyl or hydrobromic ether.

Bromide of Ethyl, Hydrobromic or Bromic Ether.—C_2H_5Br. Specific gravity 1.4733; boils at 40.7° C. It is prepared by distilling alcohol (ethylic) with either bromine, hydrobromic acid, or bromide of phosphorus; it is a colorless, trans-

lucent liquid, of ethereal smell and sweet taste. Its action upon human beings is to produce unconsciousness and anæsthesia in one minute and partial relaxation (*occasionally* complete) in two to three minutes. When given to excess it kills by direct action upon the respiratory centres. For prolonged operation it is not advisable—the limit of time is forty minutes. Impurities, free bromine, carbon, bromide phosphorus and bromoform. Should be kept in sealed tubes and from both light and air. It should not be employed except for examinations and in minor surgery and for an occasional obstetric case.

Nitrous Oxide Gas.—N_2O, obtained from nitrate of ammonia by distillation. At 226° F. the salt melts; at 460° F. it gives off gas. Purified by passing through solution of sulphate of iron and caustic potash and water. It is now to be had condensed, at a temperature of 44.60° F. (7° C.), into a liquid at a pressure of fifty atmospheres, and can be carried about in steel cylinders for convenient use. If not properly prepared the liquid gas may contain air.

The Most Prominent Local Anæsthetics.

Cocaine hydrochlorate.
Cocaine cataphoresis by electricity.
Cocaine benzoate.
Cocaine borate.
Cocaine carbolate (cocaine phenate).
Camphor phenique.
Carbolic acid.
Chloral hydrate.
Ether absolute.
Ethyl bromide.
Ethyl chloride.
Eucaine hydrochlorate.
Guaiacol, with cocaine cataphoresis.
Ice (with chloride of sodium).
Menthol (peppermint camphor).
Methyl chloride.
Salicylate of sodium.

The most important of these local anæsthetics is cocaine, active principle of the erythroxylon coca. The leaves of the plant from which it is obtained are employed as a stimulant and sustaining agent, when mixed with a little lime, and are chewed like tobacco by the Indians of Peru and South America. When making long journeys over the mountains of South America the Indians can, by its use, go for a long period of time without food. The alkaloid is prepared by maceration with lime, and distillation, and is then dissolved in alcohol for purification.

Its composition is $C_{17}H_{21}N_1O_4$. Its action is first stimulant, then narcotic. It is a powerful local anæsthetic *on the mucous membrane.* When applied to the eye it causes dryness of tissues, dilatation of the pupil and partial paralysis of accommodation. Dose, $\frac{1}{6}$ to $\frac{1}{3}$ of a grain.

Contra-indication.—Fatty degeneration of the heart and atheromatous disease of the arteries. Must be employed with caution in hysterical individuals and epileptics.

ANTIDOTES.—Amyl nitrate, free use of black coffee, aromatic spirits of ammonia, and for the depression following, minute doses of nitrate or sulphate of strychnia, $\frac{1}{60}$ to $\frac{1}{3}$ of a grain.

Amount of cocaine used must be in proportion to the extent of surface it is desired to anæsthetize. In no case should the quantity exceed one grain and three-quarters.

Cocaine should never be used in cases of heart disease, or in persons of highly nervous temperament.

In injecting cocaine the intradermic method is preferable to hypodermic. By injecting into, not under, mucous membrane or skin, the risk of entering a blood-vessel is avoided. It has been found valuable to dissolve it in a boiled solution of chloride of sodium.

During injection the patient should always be in a recumbent or semi-recumbent position; in operations upon the nose and throat, or teeth, the head should not be raised until anæsthesia is complete.

It is of great importance that cocaine should be pure, since its combinations with certain other alkalies result in poisonous compounds.

Liebermann discovered among the amorphous accessory

bases of coca leaves an exceedingly toxic substance: *Isatropyl-cocaine*, which, according to Liebreich, acts as a direct heart-poison. The last-named investigator speaks hereof as follows:

"I deem it quite probable that the hydrochlorate of cocaine, unless it be very perfectly made, also contains the afore-mentioned heart-poison, even though it be found but in traces."

Following cocaine, the next important local anæsthetic is eucaine. Its advantages are, that it is less poisonous than cocaine, but is apt to produce more burning in the eye than cocaine; but by combining the two this is obviated.

Precautions to Be Taken in Administration of Chloroform, Ether and Nitrous Oxide.

CHLOROFORM.—In employing chloroform as an anæsthetic note that there is no organic disease of the heart or kidneys; see that the bowels have been moved; but little food must be given the day before; commence with gentleness and care, and, drop by drop, pour the liquid upon a towel or a wire frame covered with a flannel. After a minute or two the strength is increased so as to get over the stage of excitement, but do not keep the towel too near the face of the patient. Watch the respiration with great care, and note the pulse for fear of heart depression in weak subjects. As a rule the head should be low.

Judge of the fitness for the operation by loss of conjunctival reflex by gently touching with the finger. Note the size of pupil for sudden dilatation, or as an indication of heart depression. If the patient vomits, turn him to one side, and with the fingers remove any solid food, and prevent its being drawn back into the larynx by a strong inspiration.

It is a well-recognized maxim that chloroform should not be administered in a dental chair, nor for the removal of a tooth.

The color of the patient's face, lips and ears is important, as great lividity, cyanosis, and pallor are all indications of danger. Watch for dropping back of the tongue, dropping of the jaw.

If chloroform must be employed as the anæsthetic, it is well to have it mixed with oxygen gas, as it is thereby made more safe.

Ether, What are the Precautions in the Use of Ether?

Commence just as you would with chloroform; give it in small quantities, and do not place patients on their backs and pour it down into the mouth, and in this way choke them in the beginning, but use it first by dropping, and then add a few drops of cologne water.

After the first stage the towel or inhaler can be placed almost in contact with the mouth, having previously anointed the lips and nose with vaseline, in which there is a small quantity of cocaine. Be careful not to give an excess of ether.

The etherizer must give his whole attention to the patient both before, during, and after the operation.

Anæsthetics are rapidly absorbed, and almost as rapidly eliminated by the skin. They are taken into the blood and reach every portion of the system.

The action of anæsthetics is secondly upon the nerve centres controlling sensation and muscular motion.

The symptoms of asphyxia are developed in the use of all anæsthetics, and are analogous but not identical with true anæsthesia asphyxia, which is quite common with nitrous oxide, less with ether, and still less with chloroform. They all produce temporary changes in the blood, but do not become permanent, unless administered in poisonous doses.

It has been found that when an animal or man is killed by ether or nitrous oxide, the arterial blood gives only spectrum lines of reduced hæmoglobin, while after death from chloroform, the lines of oxyhæmoglobin are very apparent.

Dr. Chalmers Da Costa endeavored to show that deaths under ether were the same as in chloroform, but his observations have not been confirmed.

Watch the respiration. Remember that the nervous centres regulating the act of respiration are situated on the floor of the fourth ventricle. If instead of normal respiration it is stertorous, as when breathing through the nose and mouth at the same time, irregular respiration is apt to follow, in which case the lips are partially closed, the cheeks distended, and the

nostrils dilate with each expiration, which is attended with a puffing sound.

When the respiration becomes irregular, look out; for there is danger with the use of the anæsthetic.

The cerebrum presides over the functions of intelligence and volition, while co-ordination and emotional impressions depend upon the medulla oblongata and cerebellum.

Resuscitation is the act of raising up again, or the bringing to life from suffocation or asphyxiation.

Asphyxia is the effect upon the body of non-oxygenated blood. in turn causing obstruction of the larynx, which is also produced by food, blood or other foreign substances. It is characterized by extreme lividity of countenance, prominence of eyeball, and all symptoms of obstructed respiration.

In artificial respiration the æration of the blood is produced by artificial means, by the muscles of the chest which are moved; the arms also act as levers by compressing the chest, and the elevation of them expands it. Place the patient on one side at intervals, so as to give exit to mucus, blood or water, as in drowning; employ rhythmic movement of the chest, and keep the tongue drawn out. There are some ten different methods of artificial respiration practiced, but all depend upon the principles we have announced. The jaw must always be forced forwards, as it is apt to fall back; so also the tongue must be drawn out.

Before Giving an Anæsthetic.

"Inquiry should be made before giving the anæsthetic, if the patient has any foreign body in the mouth. Also, if the patient has ever taken an anæsthetic before. The consent of the patient should in all cases be obtained, except in that of a child or in a case of great emergency. When ether is first inhaled, even when mixed with air, it is apt to cause a feeling of oppression or suffocation, which can be overcome by encouraging the patient to take a deep breath, and increasing the strength of the vapor. Then there is an interval of rest when the patient almost ceases to breathe, followed by a degree of excitement, when the

patient is apt to shout, sing or cry, swear, or even ready, when the stage is passed, to fight. Then the patient becomes quiet, and passes into the true anæsthetic state or sleep. For vomiting after ether, apply mustard plaster over the epigastrium, with the use of a grain of acetanilide every hour or by rectal injections of bromide of sodium and laudanum in starch-water. For persistent singultus, drachm-doses of Hoffman's anodyne are very effective. For vomiting after the use of ether Dr. Hare recommends the following formula: 1 grain of acetanilide, 1 grain monobromated camphor, and 1 grain of citrated caffeine, given every hour for six or eight doses.

"OXYGEN AND ETHER.—The mixture of ether vapor and oxygen gas forms a highly explosive compound. If ozonized ether is conducted into anhydrous ether, it forms a thick liquid which explodes if heated. Chloroform when mixed with oxygen undergoes no change." (Hare.)

Specific Gravity of Ether.

Specific gravity is the measured weight of a substance compared with that of an equal volume of another taken as a standard. For liquids, distilled water is the standard at its maximum density. It is found that the specific gravity of ether differs very much as given by different authorities. On p. 148, the writer has given it as 0.750 at 59° F., from U. S. P. In a recent work by Dr. Hare it is stated: "at 77° F. the specific gravity of ether should be 0.714 to 0.717. The ether which is chiefly employed in private practice and also in most of our hospitals is that of Dr. Squibb."

The writer requested the well-known pharmaceutical chemist, Mr. Frank E. Morgan, of Philadelphia, to determine for him the specific gravity of this form of ether, which he has kindly done as follows:

"*Squibb's Ether for Anæsthesia has a specific gravity of* .725 *at* 59° *F.* Absolute Ether has a specific gravity of about .718 at the same temperature."

Electricity in Resuscitation.

In applying this agent in resuscitation it must always be borne in mind that the dry skin offers an enormous resistance to the passage of the current, but if the skin is well wet with salt water the current will pass through it with facility. For general galvanization, so as to bring the whole nervous system under the influence of the galvanic current, one pole (usually the negative) is placed at the epigastrium, while the other, or positive, is passed over the forehead, or by the inner border of the stero-cleido-mastoid muscle, from the mastoid fossa to the sternum; again, along the nape of the neck to the spine. The séance should not be longer than one to two minutes, from ten to fifteen cells. If a galvanic battery is not at hand, a faradic current can be employed.

The efforts at resuscitation should not cease for less than half an hour, and requires the efforts of several assistants. In some instances, *in India*, they have kept it up with ultimate success after three hours.

The efforts should not be rough, but gentle, rhythmal and continuous, using all the rational means that are known to have given success. Never employ excessive doses of alcohol, brandy, digitalis, atropia, or strychnia. In certain diseased conditions, severe and rough treatment at resuscitation cause certain death, as in aortic and mitral regurgitation with fatty heart, hæmoptysis, and tuberculosis.

In the selection of an anæsthetic we must choose the one that is the most safe under the particular conditions of the individual case. A few important words which are to be fully comprehended by the student:

Asphyxia is the suspension of vital phenomena, a darkening of the lips and skin, and no pulse. When complete there is paralysis of the respiratory centre. Its cause may be (*a*) the anæsthetic alone, (*b*) the anæsthetic, plus venous blood, (*c*) venous blood alone, (*d*) irrespirable gases.

Blood-pressure is regulated in one of the following ways: 1. By the heart directly in the force and frequency of its beat. 2. By the heart directly, by sending impulses along the depres-

sor nerve to the vaso-constrictor centre, inhibiting its cause of this fall of pressure.

Cardiac failure, primary cardiac arrest, lowering of blood-pressure and form of heart, the incomplete mechanism as a force in the circulation.

Snycope, to faint, a temporary or permanent suspension of the functions, both of respiration and circulation, from a sudden lowering of blood-pressure, sufficient to induce stasis of the cerebral circulation and unconsciousness.

Shock may be partial, complete or reflex, the inhibition of a number of nerve centres. The vaso-constrictor centre is always more or less involved. Reflex surgical shock is a result of the reception of painful impression on the central nervous system.

Additional Means of Resuscitation During the Administering of Anæsthetics.

In "König's" method, the operator stands upon the patient's left side and faces him, and lays the open hand upon the patient's chest, with the ball of the thumb between the apex-beat of the heart and the edge of the sternum, and presses the chest-wall quickly and strongly thirty times every minute. This plan owes its efficacy to direct action upon the suddenly failing heart.

Dr. Kelly, of Johns Hopkins Hospital, Baltimore, pursues the following plan in chloroform-asphyxia:

"The anæsthetic is at once suspended, the wound is protected, and, if abdominal, a broad piece of gauze is laid over the intestines under the incision. An assistant steps upon the table and takes one of the patient's knees under each arm, and thus raises the body from the table until it rests upon the shoulders. The anæsthetizer at once brings the patient's head to the edge of the table, where it hangs extended, with the trachea and nasal cavity in line. The operator stands at the head and institutes respiratory movements as follows: *inspiration*, by placing the open hands at each side of the chest posteriorly over the lower true ribs and drawing the chest forward and outward, holding it thus for two seconds; *expiration*, by reversing the movement, by placing the hands on the front of

the chest over the lower ribs and pushing them backwards and inward, at the same time compressing the chest. The success of the manœuvre will be demonstrated by the rush of air in and out of the chest. The heart and pulse should be carefully watched. As the respiratory movements are continued, a little flickering pulse-wave will be observed at the wrist, which shortly becomes faint and regular, and gradually increases in strength. From 10 to 30 of these respiratory movements will be sufficient to excite voluntary breathing. Movements must be timed to suit the natural efforts. This method is not available in cases of patients with constricted fusiform chests (tight lacers); in such cases direct *antero-posterior* (?) compression must be practiced over the lower third of the sternum with one hand there and the other placed on the back at a point opposite the one in front."

It is stated that Dr. Kelly* has had fifteen cases, up to 1894, of resuscitations by following this method. It is to be remembered that the doctor lives in the southern portion of our country, Maryland, and we have already stated that in warm latitudes like our southern country, Africa and India, chloroform can be administered with much more safety. Again, Dr. Kelly has a large corps of both male and female assistants to carry out the various steps of artificial respiration, just as they have in India. Dr. Kelly's assistant is a most competent medical man, on whom he depends to give the anæsthetic; he has nothing else to do but to attend to this one object, and Dr. Kelly is a most rapid and brilliant operator, as we have had the opportunity to note; he is ever watchful of his patient, and ready on the instant the heart shows any indication to weaken, to direct that anæsthetics should at once be stopped, and resuscitative measures instituted. Again, he is most careful not only of the pulse but also the respiration in every case, showing he is no believer in the Sims and Lawrie doctrine of only attention to the respiration.

* Johns Hopkins Hospital Reports, vol. iii., Nos. 7, 8, 9, 1894, and illustrations kindly sent by Dr. Cullen.

CHAPTER XXIII.

Experiments of Dr. H. C. Wood and Dr. Hobart A. Hare in Reply to the Hyderabad Commissions, February, 1890, and of Dr. Hare and Dr. Thornton in 1893.

After a careful series of parallel experiments, especially in reference to the result of the influence of chloroform on dogs, were noted the following conclusions :* "As we use between us, in the laboratory of the University of Pennsylvania, many dogs yearly, a very large proportion of which are finally killed by chloroform, we may be excused for our positive statement that chloroform *is a cardiac paralyzant*, and does kill dogs by a direct action upon the heart, or its contained ganglia, especially since we have been strengthened in our opinion by the fact that Dr. E. T. Reichert, Professor of Physiology at the University of Pennsylvania, has reached results confirming our own, and has frequently demonstrated the same to the University classes. . . . . . It has been the custom of one of the authors of these experiments in his lectures before the University class to demonstrate, by means of the respiratory tembour, the mercurial manometer and the kymography, a continuation of respiratory movements after cardiac arrest through chloroform. Further than this, we have at various times taken tracings proving the same facts.

"The statements that have recently been made in the Indian journals and in the London *Lancet* have led us to re-examine the subject, and to make a series of experiments upon it with great care. We have also varied and extended these experiments in order to determine whether chloroform paralyzes the heart by indirect action through the vagus.

"The experiments show that chloroform acts as a powerful depressant poison upon respiration and circulation ; that sometimes the influence is most felt at the heart, and death results

* Medical News, February 22, 1890.

from cardiac arrest, and that in other cases the drug paralyzes primarily the respiratory centres, while in other instances it seems to act with equal force upon the medulla and heart.

"So far as practical medicine is concerned it makes little difference whether the heart stops just before or just after respiration, so that these cases in which cardiac arrest and respiration arrest are almost simultaneous, are, for the purpose of the clinician, the same as these in which heart arrest precedes respiratory paralysis.

"Finally, the results also coincide with our previous experience in the laboratory, and with what we believe to be the general belief of physiologists—that cardiac arrest is specially prone to occur when chloroform is administered rapidly and in concentrated form."

These two sets of experiments may be in part accounted for, and are given by Dr. Wood.*

He stated "that he did not desire to express any doubt whatever as to the correctness of the experimental data of the Hyderabad Chloroform Commission, but simply claimed that both his and their set of experiments, although they had yielded different results, had been properly performed. He suggested that high heat or other climatic conditions surrounding the pariah dog of India might make its heart less sensitive to the action of chloroform than the heart of the dog bred in our northern climates.

"In March, 1892, Surgeon Lawrie found that the original propositions of the Hyderabad Chloroform Commission were not received with that degree of confidence which he expected, especially the final conclusions, in which the Commission states that *chloroform may be given in any case requiring an operation with perfect ease and absolute safety, so as to do good without the risk of evil.* Dr. Lawrie wrote to Dr. Hare, asking him if another chloroform research could be instituted for the government of His Highness the Nizam of Hyderabad, who agreed to pay the entire expenses. It was stated that the express ob-

* Dr. H. C. Wood's Address on Anæsthesia read before International Medical Congress, Berlin, August 6, 1890.

ject of the research was the reconciliation of at least some of the contradictory conclusions reached by various experimenters during the past few years."

Dr. Hare* assented, and associated with him Dr. E. Q. Thornton, his demonstrator, not inviting Dr. Wood to take any part in it. The title of their paper was "A Study of the Influence of Chloroform upon the Respiration and Circulation."† We have only space to quote a brief summary of this very elaborate paper :

Summary.

"From the immense number of observations, in regard to the action of chloroform, in the laboratory and in the operating-room, it is evident that sufficient data are at hand to give us material to reach positive conclusions, and that the contradictory results hitherto obtained must have been reached by misinterpretation and error in experimental method, tinctured perhaps by opinions formed previous to the completion of a line of study. There are certain facts in regard to chloroform which few will deny, the chief of which are that it has the advantage of rapid action without disagreeable preliminary or subsequent symptoms; its bulk is small and its odor agreeable, but, more important than all, it is much more dangerous than ether.

"Though the Hyderabad Commission, in their preliminary conclusions (page 30, paragraph 43) assert that ether is as dangerous as chloroform if given sufficiently to produce true anæsthesia, we believe that the safety of ether is so universally recognized that this conclusion of the commission can only be excused by the remembrance that ether has probably been used as little by those who wrote this paragraph as chloroform is used in many parts of America. This possibility is made a probability when we read that 'if surgeons choose to be content with a condition of semi-anæsthesia, it can no doubt be produced with perfect safety, though with discomfort to the patient, by ether held rather closely over the mouth. Such a

* Now Professor of Therapeutics, Jefferson Medical College; formerly connected with the University of Pennsylvania.

† Pamphlet published by G. S. Davis, Detroit, Mich., 1893.

condition of imperfect anæsthesia would never be accepted by any surgeon accustomed to operate under chloroform.' That this statement shows, to put it mildly, that the writer knows not whereof he speaks, is proved by the universal employment of ether by hundreds of the best surgeons the world over in preference to chloroform. Further than this, medical literature contains so many statistical papers showing the small percentage of deaths from ether as compared with chloroform that this point need not be debated.

"The truth about the fatty heart appears to be that chloroform *per se* in no way endangers such a heart, but, on the contrary, by lowering the blood-pressure, lessens the work that the heart has to perform, which is a positive advantage. But the mere inhalation of chloroform is only a part of the process of the administration in practice. A patient with an extremely fatty heart may die from the mere exertion of getting upon the operating-table, just as he may die in mounting the steps in front of his own hall door, or from fright at the mere idea of having chloroform or of undergoing an operation, or during his involuntary struggles. Such patients must inevitably die occasionally during chloroform administration, and would do so even were attar of roses or any other harmless vapor substituted for chloroform.

"[We agree entirely with this statement; but as chloroform has confessedly some cardiac action and a very positive vasomotor and respiratory effect, the fatal result might be more direct.]

"Having given the evidence we have accumulated, let us see what practical deductions may be drawn.

"From a careful study of the experiments so far reported, from studies made by one of us some two years ago with H. C. Wood, and, finally, from the careful series of experiments, we believe that the question can be settled by the acceptance of both views in a modified form, or, in other words, that there is no real antagonism in the beliefs that chloroform kills by depression of the heart or depression of the respiration.

"We very positively assert that chloroform practically always kills by failure of respiration when administered by inhalation,

provided—and this provision is most important—that the heart of the anæsthetized is healthy, and has not been rendered functionally incompetent by fright or violent struggles, or, again, by marked asphyxia. By a healthy heart we mean one which has not undergone true fatty degeneration, or has not so severe a valvular lesion as to make the slightest variation in the even tenor of the circulation fatal.

"That the circulatory depression may be dangerous is not only evident, but it is stated to be so by the second Hyderabad Commission itself at the end of paragraph 8. This circulatory depression may be so profound that recovery is impossible even with the most thorough artificial respiration, a fact stated by the second Hyderabad Commission in paragraph 25, which we quote in this paper. This emphasizes the fact that we cannot afford to totally ignore the effect of chloroform on the circulation, and we cannot consider the patient in danger of circulatory failure *only* when the respiration *ceases*, BUT AS SOON AS IT BECOMES ABNORMAL.

"1. Is chloroform a safe anæsthetic?

"2. Are we to watch the pulse or respiration during the use of the drug, and what are the signs in the respiratory function indicative of danger to the patient?

"3. What is the true cause of death from chloroform?

"4. Is death from chloroform possible when it is properly administered?

"5. Under what circumstances is the surgeon to use chloroform in preference to the less dangerous anæsthetic ether?

"6. What is the best way of administering chloroform?

"To the first question the answer is, Yes, for the majority of cases, provided it is given by one who is skilled in its use and not only knows how to give it, but to detect signs of danger. It is not so safe as ether at any time, other things being equal, and never so safe in the hands of a tyro.

"To the second question the answer is, Watch the respiration, because as soon as enough chloroform is used to endanger the circulation, the respiration will show some signs of abnormality either in depth, shallowness or irregularity. In other words, the very effect of the drug may be to cause such deep and rapid

respirations that an excessive quantity of the drug is taken into the lungs, and continues to be absorbed even after the inhaler is withdrawn.

"The answer to question 3 is, That death is always due, in the healthy animal, to respiratory failure, accompanied by circulatory depression, which latter may be severe enough to cause death, even if artificial respiration is used skilfully. Death only occurs in the healthy animal when chloroform is given in excessive quantities.

"Question 4 is impossible to answer for man from the basis of experimentation, as we cannot produce identical diseased states in animals with those developed under various conditions in man. The physician, having a case of heart disease, should always advise the patient of the danger of any anæsthetic, and he should remember, whether it is wise to tell the patient or not, that anæsthesia always means a step towards death even in the healthiest of men. In the event of a death under chloroform, the physician is not to blame if he has taken proper preliminary precautions and given the chloroform properly.

"In answer to Question 5 we have several points to offer:

"1. Hot climates (where ether is inapplicable), where a free circulation of air increases the safety of the patient.

"2. Chloroform may be used whenever a large number of persons are to be rapidly anæsthetized, so that the surgeon may pass on to others and save a majority of lives, even if the drug endangers a few, as on the battle-field, where only a small bulk of anæsthetics can be carried.

"3. Its employment is indicated in cases of Bright's disease requiring the surgeon's attention, owing to the fact that anæsthesia may be obtained with so little chloroform that the kidneys are not irritated, whereas ether, because of the large quantity necessarily used, would irritate these organs. Quantity for quantity, ether is, of course, the less irritant of the two.

"4. In cases of aneurism, or great atheroma of the blood-vessels, where the shock of an operation without anæsthesia would be a greater danger than the use of an anæsthetic, chloroform is to be employed, since the greater struggles caused by

ether and the stimulating effect which it has on the circulation and blood-pressure might cause vascular rupture.

"5. In children or adults who already have bronchitis, or who are known to bear ether badly, or, in other words, have an idiosyncrasy to that drug, chloroform may be employed.

"6. Persons who struggle violently, and who are robust and strong, are in greater danger from the use of chloroform than the sickly and weak, probably because the struggles strain the heart and tend to dilate its walls.

"The safest method of administration is by Lawrie's or Esmarch's inhaler, because these provide free circulation of air and do not distract the attention of the anæsthetizer from the respiratory movement by complicated apparatus. Apparatus much like these, in allowing a free amount of air, are the Hyderabad chloroform inhaler or open-ended cone, with Krohne's and Seseman's respiration indicator attachment.

"The Junker inhaler, even with its modifications, is too complicated and cumbersome, and while less chloroform is wasted in administering the drug, it must all be thrown out of the bottle afterwards. If used at all, it should be used with the increased air-supply and respiration indicator of Krohne and Seseman.

"1. The chloroform should be given on absorbent cotton, stitched in an open cone or cap. (A depression made through the opening in the inside flannel bag will answer as well.)

"2. To insure regular breathing, the patient, lying down, with everything loose about the neck, heart and abdomen, should be made to blow into the cone, held at a little distance from the face. The right distance throughout the inhalation is the nearest which does not cause struggling, or choking, or holding of the breath. Provided no choking or holding of the breath occurs, the cap should gradually be brought nearer to, and eventually may be held close over, the mouth and nose as insensibility deepens.

"3. The administrator's sole object while producing anæsthesia is to keep the breathing regular. As long as the breathing is regular, and the patient is not compelled to gasp in chloroform at an abnormal rate, there is absolutely no danger whatever in pushing the anæsthetic till full anæsthesia is produced.

"4. Irregularity of the breathing is generally caused by insufficient air, which makes the patient struggle or choke or hold his breath. There is little or no tendency to either of these untoward events if sufficient air is given with the chloroform. If they do occur, the cap must be removed and the patient must be allowed to take a breath of fresh air before the administration is proceeded with.

"5. Full anæsthesia is estimated by insensitiveness of the cornea. It is also indicated by stertorous breathing or by complete relaxation of the muscles. Directly the cornea becomes insensitive or the breathing becomes stertorous, the inhalation should be stopped. The breathing may become stertorous while the cornea is still sensitive. The rule to stop inhalation should, notwithstanding, be rigidly enforced, and it will be found that the cornea always becomes insensitive within a few seconds afterwards.

"It is only necessary to add that the patient should be so dressed for an operation that his respiratory movements can be easily seen by the chloroformist. In the climate of India this is not difficult to manage, but it is rather more so in the climate of Europe; so that in this respect, and in this respect alone, the chloroformist in England is placed at a distinct disadvantage compared with the chloroformist in India.

"NOTE.—Since writing this report two important papers upon this subject have appeared in the London *Lancet*—the one by Gaskell and Shore, in which they carried out a complete line of ingenious cross-circulation experiments, and from which they conclude that the fall in blood-pressure seen under chloroform is due to cardiac rather than vaso-motor depression; and another paper, published by Lawrie, in the London *Lancet* for February 11, 1893, in which he refutes the statements made by Gaskell and Shore, and details experiments which he believes combat those of the two investigators just named."

An abstract of both of these papers will be found on pp. 280–299.

According to Dr. Hobart A. Hare,* Larwie's inhaler consists of four bamboo sticks supporting unbleached muslin, which

* Park's Treatise on Surgery, vol. i., p. 295.

provides a free circulation of air, and do not distract the attention of the anæsthetizer from the respiratory movement by complicated apparatus. Apparatus much like these, in allowing a free amount of air, as the Hyderabad chloroform inhaler, or open-ended cone, with Krohne and Seseman's respiration indicator attachment, the inner lining is of white felt, the outer cone is leather. It can be used directly, or by the air-pump attached to the top. Krohne and Seseman have also made a modification of Junker's inhaler, with a respirator indicator, but even with this indicator it is considered too complicated.

To Prevent the Action of Chloroform on the Heart.*

(We give also the opinion of Dr. Guérin, which is quite adverse to the theory upheld by Dr. Souchon, pp. 178, 269.)

M. A. Guérin, of Paris, stated that death from arrest of the heart might be prevented in chloroform anæsthesia, simply by having the patient inhale the chloroform only by the mouth. In death from arrest of the heart the cardiac muscular fibres cease to contract under the influence of a nasal-nerve reflex, which causes inhibition of the heart through the medium of the pneumogastric. If a rabbit be made to inhale chloroform directly through the trachea after tracheotomy, the heart is in no way affected; if, however, the animal be made to inhale it through the nose, the heart is arrested. Now, as the trachea has been cut transversely, the chloroform inhaled by the nose cannot pass the bronchi. It is, therefore, plain that the anæsthetic acts upon the heart movements only through the nasal nerves, and the cardiac nerves of the pneumogastric, the former acting reflexly upon the latter. In administering chloroform, therefore, its action upon the nasal nerves should be prevented by pressing the nose of the patients between the fingers of the hand, holding the compress until anæsthesia be produced, when the nasal fossæ, being also anæsthetized, will have no reflex action.

* France. Huitième Congrès Français de Chirurgie. Meeting at Lyons, October 9 to 13, 1894.

Dr. W. I. Fleming, in a discussion on anæsthetics, stated that he found house surgeons, as a rule, who came to Glasgow hospitals, had no knowledge whatever of the mode of using ether, and he was obliged to train them to it. He also stated the proneness of dogs to succumb to chloroform, and he had been compelled as a matter of economy to use ether for that purpose. In regard to cats the case was exactly the reverse, and to kill a cat with chloroform was a difficult thing. This important matter of idiosyncrasy did not appear to have been commented upon by the Commission.*

"I think we have not to look far to find the reason of the greater safety of ether. The full bounding pulse of ether anæsthesia shows how much the circulatory system is stimulated by it, and the rapid and deep character of the breathing proves the same influence on the respiratory organs. So if instead of using an anæsthetic which has a tendency to depress both the respiration and the circulation (as chloroform has), we employ one that has a directly stimulating effect, we are much more likely to tide these 'morituri' over their operations."†

CHAPTER XXIV.

Anæsthetics.

Their Value in Disease—Which to Avoid and Those to Employ.

First, as a rule in *diseases of the brain*, either acute or chronic, *cocaine* is to be avoided. Ether has been found one of the most valuable in brain affections not organic, when given with great care, premised with a few inhalations of nitrous oxide gas, and followed by the inhalation of oxygen gas.

* G. A. Stockwell, M.D., Detroit, Mich., Therapeutic Gazette, August 15, 1890.

† John Freeman, F.R.C.S., in Bristol Medico-Chirurgical Journal, July, 1896.

In Diseases of the Heart.—In a fatty heart there is a degeneration of the muscular fibres, or an increase in the quantity of subpericardial fat, or fatty infiltration. The former is the most serious condition, and is due to a deficiency in the supply of oxygenated blood to the heart. It gives rise to asthma, angina pectoris, and tends to syncope and sudden death. In fatty hearts cocaine and chloroform are to be avoided, while ether and oxygen gas have been found to be the remedies. In cardiac dyspnœa these two agents can be employed as anæsthetics in the horizontal posture, avoiding all hurried movements.

In aortic stenosis or valvular disease, ether is not to be employed, but a mixture of chloroform, ether and alcohol. *Ether* is to be avoided in all pulmonary diseases of an acute character.

In neuralgia, valuable results have been obtained from cocaine as a local anæsthetic, with morphia and the anode of the electrical current, or camphor with equal parts of chloroform ; also chloride of ethyl has been found useful in local neuralgic pains as a local application.

In neuralgia over various parts of the body, nitrous oxide can be employed with advantage in the middle of the day.

In nervous aphonia, not organic, with intermittent loss of voice, the inhalation of nitrous oxide gas followed by vapor of ether, will restore the voice; also hot water in tin inhaler, with compound tincture of benzoin or guaiacum, a teaspoonful in a pint of water, which must be kept hot.

Diseases of the Lungs.—Pure nitrous oxide gas can be administered with air, but do not cover the face, as it has to be carefully watched to see that no asphyxia be the result (it is also useful in aphonial bronchial asthma).

In pulmonary phthisis, as a rule, use the inhalation of the spray or vapor of menthol or eucalyptus in alboline, with a portion of bromide of ethyl, only sufficient to tide over pain if the operation is short.

When there is a tumor or foreign body to be removed from the larynx, chloroform is to be preferred to ether, but in postnasal operations for the removal of adenoid growths ether is to be employed.

When it is absolutely necessary to give *ether* in case of *slight*

pulmonary disease, on account of a prolonged operation, the patient's skin, feet and body are to be kept warm, and after the operation must be watched until reaction has taken place. Watch also that the pulse and respiration are normal. It is well to use the inhalation of oxygen gas if the skin become dark.

In all diseases of the *kidney*, especially in *Bright's disease*, or diabetes, ether must not be employed, nor should chloroform. Nitrous oxide gas with oxygen is one of the best anæsthetics in this form of disease. *Epilepsy* and *chorea*, when not of an organic character, have been benefited by the inhalation of nitrous oxide gas. Spraying of the spine by ether vapor, and the internal administration of fluid extract of cimicifuga racemosa, have been found very useful.

Nitrous oxide gas has been found useful in certain *hysterical conditions* when not dependent on organic disease of the brain.

Ether has been found a valuable remedy in *hysteria*, by inhalation or administered internally in capsules, or associated with emulsion of gum arabic with valerian, asafœtida, musk or camphor.

In insomnia, nitrous oxide gas has been found, at times, useful, but not proper if there is vascular excitement, marked arterial tension or associated with diseases of the arteries or hypertrophy of the heart. In these latter cases the bromides are found to be the most useful. At times a small dose of the atropia sulphate, $\frac{1}{150}$ of a grain, with $\frac{1}{8}$ of a grain of morphia sulphate, will relieve pain of head, from loss of sleep, only to be given at long intervals.

Sciatica can be treated successfully by the subcutaneous injections of ether or chloroform, or given internally in doses of from ten to fifteen drops, repeated morning and evening for three days, or until the patient is relieved. No local injury results by this method, as the injections are made by the ordinary method, superficially, not deep. The objections to deep freezing the skin by ether, rhigolene or ethyl chloride are that the skin becomes destroyed and ulceration and great pain follow.

In cerebral surgery, neither opium nor morphia should be employed prior to the operation.

Ether can be employed in abdominal surgery in conjunction with oxygen gas, to prevent the belching or vomiting. A small dose of hydrochlorate of cocaine has been found very useful. The more rapid the etherization is produced without air, the greater the danger of asphyxia.

Average time to produce complete unconsciousness by ether is from seven to eight minutes.

Appearance of the face when fully under ether, chloroform or nitrous oxide should be natural; any deep cyanotic appearance denotes approaching asphyxia.

The pulse at the wrist and the temporal artery should be carefully noted by the anæsthetizer or assistant.

What to do first in case of danger: "See that there is no obstruction to the respiratory passage by the throwing back of the paralyzed parts upon the larynx. Use the method of Hare and Martin (see p. 272). Place the index finger of each hand upon the corresponding cornua of the hyoid bone, while the middle fingers rest upon the angle of the jaw, and then press forward and upward, the same force serving to extend the head upon the neck; if this fails to open the glottis, then by means of a towel grasp the tongue and make rhythmic traction. If the tongue cannot be held by this means, use a tenaculum or forceps, thrust far back into the base of the tongue, and draw it forward." "According to Dr. Wood, inversion of the body at an angle of forty degrees does not resuscitate in the manner which Dr. Holmes believed when the circulation has practically ceased in anæsthesia; inverting the body must cause the blood which has collected in the extremely relaxed vessels of the abdomen to flow into the right side of the heart and distend it, and this distension, this increase of intra-cardiac pressure, may at a critical moment have an influence upon the failing organ sufficient to recall it into functional activity. The drug to be employed in cases of weak heart is full doses of digitalis given hypodermically, either before the administration of an anæsthetic or when cardiac collapse occurs."

The use of amyl nitrite will in some cases cause an increase of the pulse-wave when passed by a hand spray into the nostrils. Strychnine has been found, both by experiment and experience,

a most valuable drug in raising the arterial pressure and the rate and depth of the respiration. It should be given in full doses for a robust adult; as large a dose as $\frac{1}{15}$ grain has been given with good results. But, as we have stated before, the most wonderful results have been obtained by the use of artificial respiration, Sylvester's or other methods. Then we have the forced respiration by the foot-bellows of Dr. George E. Fell, by "which air is 'forced' into a receiving chamber, which in turn is connected with an apparatus for warming the air, and a valve which can be opened and shut by a movement of the finger. This valve in turn leads to the tracheal tube. When the valve is opened the air rushes through the chamber into the lungs and expands them; when the finger is lifted the valve shuts, the lungs contract, and so respiration goes on. Dr. Wood* has suggested a much cheaper, simpler, and probably equally efficient, apparatus, which may consist simply of a pair of bellows of proper size, a few feet of india-rubber tubing, a face mask and two sizes of inhalation-tubes. There should also be set in the rubber tubing a metal tube, similar to the tracheal canula of the physiological laboratory, so that it is in the power of the operator to allow for the escape of any excess of air thrown by the bellows."

In What Class of Cases can Chloroform be Employed with Safety?

Chloroform, in certain conditions, is a direct cardiac depressant, while, as expressed by the late Dr. Fordyce Barker, in obstetrics he had found that "chloroform had a very different effect from that which it had when given as an anæsthetic in surgical practice. The reason that he assigned for this was, that in surgical practice the anæsthetic was given to anticipate suffering, while in the case of the parturient woman, it was used for the relief of pain already existing. Under the latter circumstances he believed the system would tolerate the depressing influence of the drug, which it might not in ordinary conditions."

In our own experience, and after numerous experiments, we

* "Anæsthesia," by H. C. Wood, Pamphlet, p. 33.

would limit the use of this most potent of all the anæsthetics to *very young children*, or to those who are weak, strumous, or overgrown; to puerperal eclampsia, in very violent convulsions in male adults, or in females during delivery where rapidity of dilatation of the *os uteri* is absolutely necessary to save the mother's life.

In some rare cases of painful operation, where, after continued efforts, no complete insensibility can be produced by ether, we would feel justified in the use of chloroform on a clean sponge or inhaler.

"There are certain bodily conditions, hardly to be spoken of as disease, which would exert some influence in the selection of the anæsthetic. In his recent book Dr. Frederic W. Hewitt states that old persons whose chests have become rigid, seem not to be able to respond sufficiently to the demand made upon them by ether, and that very old persons bear chloroform practically well. In applying such a principle as this, it must be remembered that it is not the years of the person, but the extent of senile changes in his tissues, which should influence the anæsthetizer. Dr. Hewitt recommends in such cases the A. C. E. mixture; if such mixture be employed, it should always be freshly made at the time of its administration.

"Extreme obesity is another bodily condition in which it is affirmed that ether is often not well borne, producing so much excitement and respiratory irritation, as to forbid its use. Under these circumstances again, Hewitt recommends the A. C. E. mixture, but states that there are certain cases in which chloroform is necessary in order to secure sufficient tranquillity of breathing. I have not had practical experience with such patients of sufficient amount to be weighty, but my feeling is that in such cases ether should be first tried, and then, if it be not well borne, chloroform substituted, ether being again employed when quiet anæsthesia has been thoroughly established."

In this connection we feel as if it would be well to give the admirable views of an expert, Dr. John N. Upshur, Richmond, Va.,* on "The Therapeutic Application of Chloroform in

* Professor of Materia Medica and Therapeutics, Medical College of Virginia. Trans. Pan-American Medical Congress, vol. i., p. 922.

Labor." In the south of our country it is stated chloroform can be employed with perfect safety, although we have our doubts, and have expressed them freely in this edition.

"Since the primeval curse fell upon our race, and pain and anguish have been the invariable and dreaded accompaniment of man's entry into the world, to soothe woman's sorrows and conduct her safely through the crisis is an object worthy our highest effort, and one to be sought for with commendable devotion.

"To accomplish this end the administration of chloroform has become a routine practice, and the consensus of opinion from a very large number of obstetricians is in favor of its safety when thus exhibited. Careful observations for many years has tended to make me question its utility in many cases; nay, to convince me that oftentimes it adds to the peril and prolongs the trial.

"In the light of the foregoing facts I most earnestly avow my belief that we, as physicians, should place chloroform upon the same platform as other drugs, and not be influenced by our sympathies aroused by the pleadings of patients or the fashionable routine practice of the day, but initiate and sustain a much needed reform in our obstetric work, chloroform being administered, as other agents, when the indications in the case imperatively demand it—not unless. He is a bold man who, invading the domain of nature, interferes with her physiologic processes and places the wife and mother in a position of increased peril, and perchance in the shadow of a fatal issue, or at least of a life of invalidism and suffering, where before the home was irradiated with the effulgent rays of the sunlight of true and unalloyed happiness."

CHAPTER XXV.

The Legal Responsibility of Physicians in the Administration of Anæsthetics—Medico-legal Relations of Anæsthetics—Experiments of M. Dolbeau—Case in Philadelphia of a Surgeon Dentist—The Important Question whether Chloroform can be Administered for Criminal Purposes?—Cases in France, England and the United States—Dr. N. L. Folsom, R. M. Denig—Chloroform as a Poison—The Chloroform Habit—Hypnotic Anæsthesia and its Analogous States in their Various Aspects.

On the Legal Responsibility of Physicians in the Administration of Anæsthetics.

It is a noted fact, that when anæsthetics are trusted in the hands of an educated and careful surgeon, the mortality from their use is reduced to the minimum. The individual who administers the anæsthetic should have nothing else to do; his hands, eyes and mind should be on *this alone.* In our hospitals, clinical assistants should be instructed for at least six months in the chemical, physiological and toxicological nature of anæsthetic agents, and after being thoroughly trained in their use, and in the means of resuscitation, receive a certificate of competency. This is done in the Philadelphia Dental College after a careful examination by the professors and an expert. It is too often the case that valuable lives are placed, as it were, in the hands of young men who have no proper knowledge of their use, and who do not appreciate the great responsibility under which they are laboring. Such powerful agents as chloroform and ether, or their compounds, should be handled with skill, judgment and discretion, fully realizing that on the exercise of these depends the life of the patient. There is no doubt that many deaths have been caused through the want of this proper knowledge and experience. Who is at fault in this? It is, as a rule, the fault of the medical schools and of the operating surgeon, who, in a general way, considers this as a secondary matter, and trusts the anæsthetic to any person who may be

with him. To the experienced eye signs of danger are almost always evident—the disturbed, stertorous, or shallow respiration, the pulse, the pallid or leaden hue of the skin, the fluttering heart; but on the novice or recent graduate these make little or no impression.

We repeat it, that a physician or a surgeon, in administering ether and chloroform, or their compounds, is responsible for the life of the patient, and it would be well for some of them if laws were enacted compelling them to employ the least fatal anæsthetic, unless some idiosyncrasy on the part of the patient did not allow of the use of such an agent, or one less dangerous. Again, in our navy, especially on board steamers, and in countries where the average temperature is 80° F. or over, chloroform might be allowed, but in the army, in the field, as well as in the navy, only in capital, very painful or extensive operations, this exception being enforced by a rule.

Daniel S. Riddle, Esq., New York, said, as regards the enactment of further laws on this subject, it was not necessary. There are sufficient laws already. The difficulty is in enforcing them. If there is carelessness on the part of the doctor, he should be held responsible. It is the same with lawyers. It belongs to the profession of medicine to say whether these agents have been carelessly used; and if they have been carelessly used, it is their duty to produce, as well as indicate, the person who uses these great powers carelessly. "If we lawyers," he remarked facetiously, "find out that you are carelessly using these things, it is our duty to pitch in."

Coroner Ellinger thought it would be a hard matter to hold doctors responsible, because it is difficult to state scientifically where the responsibility can rest. It ought at least to be shown that there was conscious negligence in the performance of duty. The condition of the patient should be taken into account, and that must be left to the discretion and knowledge of the attending surgeon. He thought that the medical student ought to be taught the danger of the agent he employs, how and when to use it judiciously, and should be required to secure a certificate to the effect that he has been so instructed before being let loose upon the public. The public would then

know that he possesses a knowledge of the agent which he employs. Beside, the physician would be conscious of a certain moral responsibility, for he held that the moral responsibility which every medical gentleman must feel, is greater than the responsibilities placed upon him by the laws of the land.

Jacob F. Miller, Esq., agreed with those who advocated care in the use of these agents. Man is living in the midst of dangerous forces, and will continue to use them, though of necessity many deaths occur. But in order to rest a case against the user, it is necessary to show negligence. Negligence is the gist of the action. The physician, surgeon or lawyer contracts for the ordinary skill and care of his profession. He does not contract for any extraordinary skill. The law does not hold him any more responsible than that. It would be unreasonable to do so, because few persons could safely practice their profession; and if any person should use anæsthetics, and the patient should die, that is not sufficient to charge him with the responsibility. He thought that all would admit that if a man not having the ordinary skill of his profession should, by unskilful administration of anæsthetics, cause the death of the patient, he should be prevented from doing further damage by a suit for malpractice. Would it not be better to stop him by such procedure? Shall a man be allowed to use such dangerous forces just as he pleases—let the consequences be what they may? People consult physicians because they say they have the requisite skill to use these things. They hold themselves out to the community as having this skill, and they ought to possess it; if they do not, and harm results from it, they ought to be held responsible. The coroner says that physicians are actuated by moral responsibility, which is no responsibility at all. The quack will go on with his practices until he is stopped by the law. Where is his moral responsibility? What does he care? His practice only goes to show that he has no moral responsibility. *That lawyers should check such practices is due to the profession, to the public, and to God. But before they take a case of malpractice they ought to be convinced that there is malpractice.* It may be all very well to say that negligence is the gist of an action. If it cannot be shown

that there is negligence, the case should not be taken, for when the case arrives at the courts you must show that the defendant is guilty of neglect, and that is done by calling upon a physician who is able to say where negligence has been committed, and that he is guilty of it. This evidence is necessary; lawyers cannot get along without it.

Mr. Max F. Eller spoke of the *fact* that, for any action, as many "experts" could be obtained by one as the other, provided enough money is paid for such expert testimony. Some will say the patient should have been notified of the danger; others that he ought not. Some will say the chloroform killed him; others not. For that reason he thought that before making any more laws regarding the proper administration of anæsthetics, those which already exist should be administered in a better manner, and physicians should be a little more careful how they administer anæsthetics.

Mr. Eller referred to the popular fallacy that chloroform could be used successfully for the purpose of effecting robbery. He thought that that delusion ought to be dispelled, for the time between the actual administration of chloroform and the period of annihilation of sensation, is sufficiently long to render the accomplishment of the object impossible. Such a plea is used by criminals to shield themselves from the consequences of their own crimes. In this we differ from Mr. Eller, and have collected some important evidence in its favor.

A correspondent of the *Societe d'Hygiene et de Medicine Legal*, Paris, having been interrogated as a judicial expert as to "whether the employment of narcotics, in the liquid or gaseous state, can produce an anæsthesia so profound that violation of the persons to whom it has been given may be perpetrated without awakening them," gave an affirmative answer.

M. Dolbeau, apropos to his judgment, made a series of researches, the results of which were laid before the society. He limits the question to the employment of chloroform, and starts with the following proposition:

"*Can chloroform in vapor be administered to a person who is sleeping naturally, to the production of anæsthesia, without awakening him?*"

In M. Dolbeau's experiments the chloroform was given in the usual manner, on a cone held an inch or so above the nostrils, so as to enable a constant view of the countenance.

In the first series of experiments three patients out of four were awakened by the chloroform inhalations; in the second series, four out of six ; in the third, only three out of nine.

It is not without interest to observe the increasing proportion of subjects anæsthetized; the manual dexterity acquired by the experiments is not without influence upon the results obtained. Accordingly, as a result of his experiments, M. Dolbeau believes himself authorized to formulate the following conclusions:

"Scientifically, it is difficult, but often possible, to cause insensibility by means of chloroform in persons who are sleeping a natural sleep. Certain precautions—the employment of a perfectly pure agent and experience—are also conditions which favor the attempt at anæsthesia.

"It is probable that certain subjects are absolutely refractory—that is to say that it is impossible to anæsthetize them without taking every precaution. Others, on the contrary, particularly young children, submit easily to anæsthesia without having been awakened by the irritation produced by the anæsthetic agent in the air-passages.

"From a criminal point of view it is certain that chloroform, administered to sleeping individuals, may facilitate the perpetration of certain crimes. It is, however, probable that the conditions favorable to anæsthesia are rarely found on the occasion of criminal attempts. In justice, the expert should declare that it is possible, but not easy, to render a person who sleeps, so insensible by chloroform that the said person might become the victim of any violence.

"The responsibility attending the use of anæsthetics is of great importance to medical men, as frequently their personal and professional reputation is at stake; it is therefore always better, in the administration of an anæsthetic *to a female*, to have some reliable person present. This is especially necessary when ether or chloroform is employed."

During the early period of the author's medical career, soon

after graduating, we had in our Quiz class a young, ambitious dental surgeon, one of the most gentle and amiable of men, who was desirous of obtaining the medical degree, which he ultimately attained. Soon after this the man was married, settled in this city, and acquired a large business. At that time it was common for the dentist to administer anæsthetics in their office without an attendant in the extracting of teeth, etc. He had a young female patient to whom he administered chloroform alone, and who afterwards stated that he had taken improper liberties with her person during this state. This case caused great excitement in our city, and the public sympathy was with the young female, and a suit was instituted in which damages were claimed. The case was argued by distinguished lawyers on both sides, and voluminous testimony taken. The judge charged the jury, and the sentence was ten years' imprisonment. Subsequently the sentiment of the community changed, and it believed it was all the result of her vivid imagination, and that she was laboring under a delusion. The majority of physicians and dentists signed a petition, and the sentence was remitted.

"It is stated by Taylor 'that the vapors of ether and chloroform have been criminally used in attempt at rape. In a case which occurred in France, a dentist was convicted of this crime upon a woman to whom he had administered the vapor of ether.' Now this may be just such a case as the one in our own city. Ether, from its disagreeable taste and irritating vapor, is much more difficult to administer forcibly and against the will of a patient. The numerous stories of anæsthesia by simply placing a few drops on a handkerchief under a patient's nose or mouth are in the majority of cases perfectly absurd, as the shortest time required to bring a patient fully under the influence of either of these drugs—even when forcibly held in contact—is from two to ten minutes, and if subsequent rough handling takes place the patient is at once roused to make resistance by struggling. We were once called to a woman who had been in the habit of employing chloroform by inhalation from a small bottle to cause sleep; she accidentally, when in a drowsy state, let the open bottle drop on the pillow,

and its contents saturating the covering, she lay with her face in it. But instead of making her sleep soundly, it produced most distressing nausea, and her family were awakened by her efforts at vomiting, and so her life was saved, she not being able to arouse sufficiently to get rid of the offending matter, which would have lodged in her trachea, or the contents of the stomach might have been brought into the bronchial tubes by deep inspiration, and thus have caused suffocation. But it is not always the result, as persons have employed this means to produce death and have been successful."

The former case in Philadelphia settled the important point in the minds of medical men of this city that this incomplete unconsciousness does not coexist with complete motor and sensory anæsthesia, and, therefore, anæsthetics are employed without any fear in all important operations. These observations are, in part, corroborated by two learned authors in a recent and most admirable work on medical jurisprudence, in which they state:

"A question of some importance to the medical jurist naturally occurs here, namely: '*Whether chloroform can be administered for improper purposes?*' We know, however, that insensibility from chloroform (and more slowly from ether) vapor is only slowly induced. It would be difficult, therefore, to administer chloroform forcibly and against the will, while, of course, the stories of immediate anæsthesia produced by it are but idle fables. Still, it might be administered to persons asleep without much difficulty, and this seems the only possible condition under which it could be conveniently used for improper purposes unless considerable force were employed to prevent the person struggling, which, under ordinary circumstances, would be an almost insurmountable difficulty to its use."

The following case,* which occurred in England, more completely confirms our case of the condition of semi-anæsthesia:

"A case of the utmost importance to the whole profession, not in Great Britain only, but everywhere, was tried before Mr. Justice Hawkins, at the assizes, at Northampton, on the 9th

* Philadelphia Medical Times, December 22, 1877.

of November. It was a charge against a surgeon's assistant of criminal assault—of rape upon a patient when under the influence of chloroform. If there is a dastardly crime, it is to take advantage of a woman's helpless unconsciousness to violate her person. And so the magistrate thought who sent the accused to jail, on the 14th of September, declining to hear anything in his favor, and resolutely refusing to accept bail. The charge was that a married woman, named Child, went to the surgery of her family medical attendant to have her teeth operated upon. She had been there a day or two before, but the attempt to put her under chloroform then failed. A second attempt was rather more successful. She evidently had some peculiarities or idiosyncrasies in relation to chloroform, for he gave it for an hour, and yet she was never sufficiently under its influence to admit of the operation being performed. She was accompanied by a friend—a Miss Fellows. At the end of the hour, Miss Fellows went out of the room. In a quarter of an hour Miss Fellows returned. The prosecutor maintained that, on Miss Fellows's return, she was quite conscious, but unable to speak. Finding it impossible to perform the operation, the accused accompanied the prosecutrix and her friend home. So far, Mrs. Child had been unable to speak, but shortly after the accused left the house she complained to her husband that he had taken advantage of the absence of Miss Fellows to assault her criminally. Next day, when the accused called, he was told about what she had said, and he replied that she was laboring under a delusion. Under cross-examination, Mrs. Child said that she told the accused that if he would admit the offence and quit the town (Birmingham) she would forgive him. This the accused declined to do, denying that he had committed any offence. He was then given in custody. The prosecutrix stated that the offence was perpetrated immediately after Miss Fellows left the room; that the prisoner went upon his knees, and then assaulted her. Miss Fellows stated that on her return she found Mrs. Child in precisely the same position in the chair which she occupied when she went out of the room. Such were the facts of the case. It was quite clear that there had been either an assault committed, or that

the woman was under the influence of a very pronounced delusion. The whole of the accused's conduct was in favor of the latter hypothesis. But in such a matter, where no third person was present, the statement of one of the two parties concerned must be taken. When a woman whose character was apparently without blemish (for in cross-examination no attempt was made to call her reputation in question) makes a definite charge against a man of assaulting her under circumstances which permitted of such an assault, the law could only send the case to a jury. In the meantime, the unfortunate surgeon's assistant was sent to prison.

"When the case came to be tried, a large number of medical men of repute came forward voluntarily to aid the accused's defence, and did this quite gratuitously. The chief witness for the defence was Dr. B. W. Richardson, F.R.S., whose celebrity is world-wide. As is well known, Dr. Richardson has studied anæsthetics very carefully and for many years. He stated that there were four stages or degrees in which chloroform operated. The first stage was that in which consciousness was not lost; there was resistance and a desire for air. In the second, consciousness is lost, but the operation is impossible, the patient screaming, often without provocation. The third stage is that of complete unconsciousness, and where all rigidity is lost. This is the stage which permits of operation. In his opinion, the patient was in the second stage, the third never having been reached. He stated that, in his own experience, he had known persons in this second stage to have delusions as to what had taken place during that time. He related a number of cases, and stated that the fact of such delusions being induced by chloroform was one of the earliest objections raised to its adoption. He related one case, where the patient, a female, was being operated upon by a dentist, and alleged that the dentist criminally assaulted her. And this she persisted in, though her father, her mother, Dr. Richardson and the dentist's assistant were all present throughout the whole time. She persisted in her conviction long after the effects of the chloroform had passed away, and Dr. Richardson said she was probably of that belief still. This evidence of Dr. Richard-

son's was corroborated by the experience of Dr. Hawksby, of London, and by Dr. Saundby and Mr. J. F. West, of Birmingham. The judge asked the jury if it was necessary to sum up, and they replied it was unnecessary—they were already agreed upon a verdict of acquittal. Mr. Justice Hawkins pointed out that such a verdict would not be the slightest imputation upon the absolute sincerity of the prosecutrix, who, no doubt, firmly believed every word of what she had said. He then congratulated the accused upon having had an opportunity of fully vindicating himself from the charge preferred, and said that the verdict of acquittal did not mean that there was insufficient evidence, but that the accused was entirely cleared of any imputation in respect to the charge preferred against him. There could be no doubt the prosecutrix labored under a delusion. The accused was then discharged from custody, having been in prison two months for no offence. It is not merely that this unfortunate man was imprisoned for two months for an imaginary offence, but that any man who is present when a woman is being put under chloroform is liable to have the same charge brought against him that gives this case its gravity and importance.

"Such being the case, it becomes necessary that a little more should be known amidst the profession, as well as the laity, as to the occurrence of erotic sensations in women. The subject is not a pleasant one, but that is no reason why it should not be investigated. If it is a fact, and there is no doubt about this, that women, when being put under chloroform, are liable to those erotic sensations which they experience from sexual intercourse, the sooner the fact is generally known the better. It is just the mystery which surrounds such facts that permits such a monstrous hardship as that mentioned above to be a possibility at all. Of course, it is obvious enough to any one that it is a delicate matter to inquire into the subjective sensations of women. But if these subjective sensations take the practical form of a charge of rape, two months in jail and a trial by jury, they pass from the domain of sentiment and enter that of stern reality. Few, comparatively few, of the profession seem to

be aware that women are subject to conditions and sensations identical with those associated with the sexual act, which arise quite subjectively and without any extrinsic stimulus. The delusion of St. Catharine, that the devil visited her every night, and enjoyed her person when she was asleep, and could offer no resistance, is no unique experience, but one common enough to women. Every one familiar with asylum work knows that a certain percentage of women patients have this delusion, among others, that the medical superintendent comes nightly to their bed, and violates their person during sleep. Of course there is no foundation of any kind for such delusions, except the subjective sensations of the woman herself. How strongly such a delusion, however, may be fixed in a woman's mind is evidenced by the case related by Dr. Richardson, where a woman persisted in her belief, though her own father and mother, as well as others, were present, and where such an assault was physically impossible. Such being the case, it behooves every man who is to be present with a woman when she is to be placed under chloroform to see that there is at least one other person present, and that, too, the whole time, without intermission, during which the woman is under the influence of chloroform, and that such other precautions be taken as will preclude the possibility of such a charge being raised. That Mrs. Child charged this unlucky man in good faith need not be questioned for a moment. She was far from being hostile to him, for she offered if he would avow his guilt and leave the town she would forgive him. The charge was not pressed from any rancorous spite; that is abundantly clear. But it is equally clear that something had occurred to that woman which she interpreted into the sexual act, and that this was so firmly fixed in her consciousness that it could not be dislodged. It becomes necessary, then, that the subjective sensations of women should be investigated, and made the subject of scientific observations; and seeing that they exist, they must have a scientific value; and that no prudishness should prevent attempts being made to ascertain what the actual facts are, and what is their interpretation."

The following is the experience of Dr. N. L. Folsom, of Portsmouth, New Hampshire, in the same line:

"In 1854 a clergyman's sister came to my office for the purpose of taking ether and having a tooth extracted, and brought her brother's wife with her. I began to administer the ether to the patient, and whilst renewing it she got away from me, and seemed alarmed and offended. I did not attempt to compel her to breathe any more ether, but urged her to take it, and so also did her brother's wife, but she would take no more. She had the impression, so her brother told me, that I attempted to violate her, and that his wife assisted me. It was a long time afterward before she would fully give up that she was mistaken in the matter."

We are almost certain, after a number of careful experiments, that chloroform and ether can be administered in sleep, so as to produce the first stage of anæsthesia, and can be carried to full completion or total unconsciousness. Still, this is rare without disturbing the patient's stomach, causing nausea, or irritation of the lungs, with risk of sudden death, by its dense vapor, and thus rousing him or her to consciousness, or a condition in which the patient can resist its influence if the party is willing to make the effort. Another important point is that loud talking or handling, even in some cases the slightest touch or pain in any way, will cause the patient to start and rouse him to resist. In the case of ether, the patient can almost always see distinctly, and in some instances is able to talk during the anæsthetic state.

Attention has been directed by Dr. J. M. Quimby, of Jersey City, N. J., to certain facts connected with the use and abuse of chloroform, and from these facts inferences have been derived which may be interesting and instructive to the profession, confirming the power of the physician to place his patient under an anæsthetic while asleep.

He states, "that in consequence of the recent murder of Policeman Smith, in Jersey City, while he and his wife were supposed to be asleep in bed, his wife was arrested as a *particeps criminis.* She denied the charge, and asserted that she had been chloroformed during sleep, and therefore was innocent of the crime.

"The State denied this, and contended that it was *impossible*

for her to have been chloroformed in that way; that the fumes of the chloroform would have certainly awakened her from her *natural sleep*, and *therefore she must have known who the murderer or murderers were.*

"Here, then, as will be seen, arose a very *nice* and *important* medico-legal question, viz.: whether a person could be chloroformed whilst in natural slumber without first being awakened, or, in other words, whether the application of chloroform, properly given, would awaken the person to whom it was applied; or, could such person pass from the natural to an artificial sleep (or chloroform sleep) without being aroused by its application?

"Mrs. Smith asserted most positively that she was chloroformed while she was asleep in bed with her husband, and knew nothing about the murder until she awoke in a bewildered condition, feeling the cold elbow of her husband pressing against her side. It may be stated here that there was found in the room of the murdered man a bottle partly filled with chloroform and a folded towel with bloody finger-prints, which Mrs. Smith asserted was upon her face when she awoke. She also described quite accurately the taste, smell and pungency of chloroform.

"Without going into further details, the counsel for Mrs. Smith applied to me to know if it were possible to transfer a person from a natural to an artificial sleep by the use of chloroform without first arousing the sleeper from his natural slumber. I replied that I had never attempted the application of chloroform to a person while in a natural sleep, and that books, as far as I knew, were silent on that point; although I thought there would be no difficulty, if proper care were taken in administering the chloroform, in transferring a person from the natural to an artificial sleep.

"I was strongly urged on the part of Mrs. Smith's counsel, and in behalf of humanity and justice, to settle by experiment this disputed question. To accomplish this result I made the following experiments: I made arrangements with Mr. A. to enter his room in an hour or two after he had retired, and when he was asleep apply the chloroform, which I did with entire

success, transferring him from the natural to the chloroform sleep without arousing him from his natural slumber. I used about three drachms of Squibb's chloroform. and occupied about seven minutes in putting him to sleep. The second case was a boy, aged 13, who was suffering from an ingrowing toe-nail. He refused to allow me to touch him with knife or forceps without etherizing him, and when I attempted to apply the ether he screamed and struggled so desperately that his mother became frightened, and asked me to desist from giving him ether. In this dilemma I advised the mother to take the boy home and put him to bed with a light supper, and I would call at the house between nine and ten o'clock that evening, give him a little chloroform, and remove the nail without the boy knowing anything about it.

"I called at the time agreed upon, with my friend, Dr. Cahill, and found the boy quietly sleeping. I applied the chloroform, divided the nail in the centre, and removed the two segments by the application of forceps without awakening the patient or his having any knowledge of the operation until next morning, when he awoke, and, discovering the condition of his foot, remarked that had he known 'it would not hurt any more than that he would have had it taken out at the office, and was ashamed that he had made such a fuss about it.' "

"Case No. 3 was a boy, aged 10, who was brought to my office suffering from a swelling over the lower jaw, which proved to be an abscess due to decayed teeth ; but the boy would not let me come near him with either lancet or forceps ; so, as in previous cases, I advised his mother to take him home and send him to bed with a light supper, and that I would call at the house after he got asleep, administer the chloroform, open the abscess, extract the teeth, and he would know nothing about it ; all of which I did without arousing the boy.

"I remained with the patient about one hour after the operation, to attend to any hæmorrhage that might occur, and to observe if any change would take place when he would pass from his artificial to his natural slumber again.

"Finding there was no change in that time I left, requesting the parents to watch him and let me know exactly at what hour he awoke.

"When I called next morning, they reported that he awoke at six o'clock, exclaiming, 'I must have swallowed my teeth, for they are both gone!'"

"BEWARE OF CHLOROFORMING WOMEN WITHOUT AN ATTENDANT!—At Oakland, Cal., during July, 1880, a bank teller, named E. F. Schrœder, killed Dr. Albert Lefevre, a prominent dentist of that place. It appears that Mrs. Schroeder went to the train on the day of the shooting to meet her husband. Mrs. Schroeder told him, that on the Saturday previous, while under the influence of chloroform in Dr. Lefevre's office, the dentist made a felonious assault upon her. Schrœder at once proceeded to Dr. Lefevre's office and committed the tragedy. It is believed that Mrs. Schrœder's charge against the dentist is purely illusory. Such hallucinations are not uncommon after chloroform administrations. Some remarkable cases exist where hallucinations of this nature have taken the form of absolute conviction in the minds of persons laboring under them, although there exists abundant evidence to prove that this conviction was utterly unfounded. The coroner's jury rendered a verdict charging Schrœder with murder. We know of an instance in which the presence of a third party saved a like imputation against the character of an innocent practitioner. The lady herself beyond reproach still had such an illusion after recovering from the administration of the chloroform."

"PROSECUTION OF A DENTIST.—At the Manchester Assizes, before Mr. Justice Day, an action was brought against Mr. James Jackson, a dentist, of Burnley, in which the plaintiff, Mr. Robert Jackson, farmer, sought to recover damages for the alleged seduction of his daughter while under the influence of nitrous oxide. There was also a cross-action for slander brought against the plaintiff. The trial occupied nearly three days.

"His Lordship, in summing up, said the one substantial issue for the jury was, did James Jackson, the dentist, or did he not, administer gas or some narcotic to the young woman, Margaret Ann Jackson, and did he, while she was under the influence of some anæsthetic, criminally assault her? That was the question they had to determine, and it was a question of the very gravest moment. The consequences to the one side

or the other must necessarily be of the most serious character. The charge which was made against the dentist was one of assault under circumstances of the most aggravated and nefarious nature. The charge, on the other hand, of which the woman would be guilty, if she had made a false accusation, was one of the most wicked, odious and vile that could be brought by one human being against another. The case was one of a most extraordinary character, and one which, he was happy to think, was very rarely raised in a court of justice. It was one which demanded at the hands of the jury, as he knew it would most assuredly receive, their deepest and most anxious attention, so that to the utmost of their ability they might do justice between the parties. He did not hesitate to say that the question was of an extremely difficult character, but it was one which he was confident the jury would, using their own good sense, solve to their thorough satisfaction; and if they did solve it to their satisfaction, it should be satisfactory to all well-minded people. He would say nothing about damages, because it was unnecessary. The parties probably were none of them in a position to pay damages. That, however, was utterly unimportant, and should not affect the amount of damages. It was unnecessary for him to say a word about damages, because he should not venture to put any limit upon the damages which they might award to the one side or the other.

"The jury retired to consult on the case, and after deliberating for three hours returned to court and stated that there was no possibility of their coming to an agreement. The judge thereupon discharged them."

Chloroform—Its Action as a Poison.

Chloroform is an irritating poison. In a case quoted by Taylor, an individual swallowed four ounces. He was able to walk a considerable distance after taking this large dose, but subsequently fell into a state of coma. The pupils were dilated, the breathing was stertorous, the skin cold, pulse imperceptible, and there were general convulsions. He recovered in five days. A second case reported, swallowed nearly two ounces and recovered, and a third swallowed two ounces, but he died

in six hours afterwards. In this case the pupils were fully dilated, the breathing was stertorous, and the skin covered with a cold perspiration. On inspection, the lungs were found much engorged with blood, and there were some apoplectic effusions in these organs. The stomach was slightly inflamed in patches and the mucous membrane was softened.*

A physician, æt. 57, swallowed three ounces of chloroform. He immediately began to stagger, as if intoxicated, vomited, sank into a deep stupor, and was in a state of complete anæsthesia. His skin was pale and tolerably warm; the muscles were relaxed, the breathing short, and the action of the heart weak and intermittent. In about fourteen hours sensibility returned. Acute gastritis ensued, with rapid collapse, and proved fatal in twenty-nine hours from the time the chloroform was taken.†

TREATMENT.—In poisoning from liquid chloroform, the stomach-pump and emetic should be resorted to. If evidence of suspension of the action of the heart (syncope) exists, there should be a free exposure of the face to a current of air, compression of the chest and artificial respiration, warm applications to the chest, with an inversion of the body, active friction and stimuli externally and by the rectum. The poles of a galvanic battery, applied to the chest and side of the neck, with sponges dipped in hot water, should be used. Solution of ammonia in water has been found useful when injected hypodermically, and strychnia, in the same way, to act upon the respiration. Aromatic spirits of ammonia must be given with water, and great care taken of gastritis and disturbance of the liver, which are apt to follow in the convalescence of the patient.

The Chloroform Habit, or Chloroform by the Mouth.

I have received the following letter from a friend on the chloroform habit, and sent him my reply:

* American Journal Medical Sciences, October, 1866, page 571.
† American Journal Medical Sciences, January, 1870, page 276.

"SHELBOURNE, MASS., May 29, 1890.

"MY DEAR DOCTOR:

"What I wish to know is whether chloroform, given by the mouth, is good and *safe* practice. I have given it several times that way, and always had good results. There is a doctor in this town who is a chloroform inebriate, and I have known him to take *thirty-four* ounces (34 ℥) of chloroform in twenty-three hours. He always gave his patients chloroform for everything, and usually gave it by the mouth. For a small operation he gave a teaspoonful in a glass of wine, and told them to breathe rapidly through the mouth. It acts quickly and very nicely. I have never seen any authority for administering it by the mouth, and have wondered lately if it were safe practice. If you should find a leisure moment some day, should be pleased to know your views on the subject. If safe, I prefer giving it that way in many cases. Yours,

"H. H. FLAGG."

The writer's answer was, that he considered chloroform given by the mouth neither a safe nor judicious practice, as death may follow by paralysis of the heart. The fatal dose is given in recent works in the table of poisons as ʒj (see *Gould's Dictionary*), the treatment of which is as follows: Draw the tongue forward for air, use artificial respiration, faradic current, hot and cold douche, amyl nitrite.

The chloroform habit is usually the result of its secret use, and is considered most degrading to both body and mind (see Chloroform as a Poison, page 531).

Transitory mental and muscular excitement, similar to that referred to when dealing with the after-effects of ether, may occur in hysterical and neurotic subjects. Delirium lasting three days has been recorded.* Loss of speech† (attributed to cerebral hæmorrhage) has also been supervened after chloroformization. Persons who have had maniacal attacks before the

* See an interesting pamphlet, "Ether as an Anæsthetic," by Josiah de Zouche, M.D., of Otago, in which delirium lasting three days in a boy of 14 was met with after chloroform-inhalation.

† *Lancet*, vol. i., 1870, p. 553. Chloroform was given for a tooth extraction. The aphasia lasted five weeks.

administration of chloroform, have been known to suffer from a recurrence of their mental disorder after the use of this anæsthetic.*

Hypnotic Anæsthesia and its Analogous States in their Various Aspects.

While spending the winter in France (1893) there was placed in my hands, by a scientific layman, the work of "La Tourette" on *Hypnotism*. It was shortly after the time that there had occurred a newspaper controversy between a distinguished medical editor of London and an ancient physician of Paris, the latter of whom had given unusual prominence in his practice to the agency of hypnotism, while the former, after experimenting with a number of his cases, believed the doctor had been deceived in them.

Having, in my previous edition, brought forward this agency as a means of producing a certain form of anæsthesia, which can be employed in certain rare surgical operations, I have endeavored to improve the opportunity to study the subject more in detail, especially in its anæsthetic and medico-legal aspect, so as to make my work more useful to my medical, dental, and scientific confrères. Hypnotism is still being tried in the alembic of the medical and scientific mind, its friends still holding to certain results, obtained by the most carefully conducted experiments, while others give it a very high estimate far beyond what it deserves as a nerve agent. Yet, from what has been seen, we must not be too skeptical. The late Prof. Charcot answers the skeptics as follows: "In presence of the evidence of facts presented, scientific skepticism is only an arbitrary skepticism."

No one with average intelligence can help being impressed with the fact that certain hysterical individuals can be placed in a so-called hypnotic condition or state by individuals, or by constant gazing intently, for a given time, at a bright object, like metal, brought near to the eyes of those susceptible. While the individual is in this condition, certain phenomena can be produced.

* See Savage, *Brit. Med. Journ.*, Dec. 3, 1887, p. 1199.

The following is an abstract of the history of the hypnotic state. Propositions of Mesmer (Animal Magnetism) 1779. The theory of universal magnetic attraction. The report of the secret Royal Commission demanded of Mesmer. by Louis XVI., describing the various symptoms produced and some important medico-legal facts. In 1784 Payseger discovered how to produce artificial somnambulism, and described successful magnetism, 1821. Discussions of the Academies of Paris by Du Potet Foessa and the Report of Husson, 1825–1834. The prize of Beerdin, 1837–1840.

The discussion in the Academie of Medicine of its medico-legal importance and the institution of the Penal Code. Then follows the Neurypholögie of "Braid;" but no great scientific progress was made until 1878, when "Charcot" and "Brouardel" took up the subject and made long, careful, and elaborate experiments, and came to the following conclusions as to its medical application and therapeutic uses.

Hypnotism as an Anæsthetic.

Hypnotism (from *hypnos*) is the production of sleep by what was generally known as animal magnetism. Only certain individuals are susceptible to its influence. The person who operates has, in our opinion, great will power over the individual operated upon. The patient hypnotized is not absolutely insensible, but operations of a trifling nature can be performed without apparent pain.

It is stated by La Tourette that excellent effects have resulted in the treatment of accidents and complications, from the use of hypnotism, in certain forms of contractions of muscles and paralysis; also in mental alienation and manifestations of hysterical delirium.

Therapeutic Hypnotism.

It is quite well known, according to "La Tourette," that a course of action suggested to a hypnotized person is followed irresistibly and unconsciously by that person after, as well as during, the hypnotic state. Upon this is based the medical application of hypnotism. If a subject can be made to carry out useless, eccentric, or, in some cases that have become known,

even criminal suggestions, without his own knowledge of the character of the cause of his action, why, ask the scientific experimenters, may not the same cerebral mechanism be brought into play to influence the physical state of persons suffering from certain kinds of disorders? The influence of the mind and the imaginative faculties on the body in such cases has long been known; and it is maintained that this kind of suggestion does not differ, in reality, from that of the hypnotic state. Whatever may be the cause which excites the nervous centres of the brain to intervene in order usefully to modify the organic function of the body, the process, say these investigators, is the same.

Reports submitted at the late congress in Paris, the treatment of invalids in this manner already shows some remarkable results. Two physicians of Amsterdam told of 414 cases they had treated by hypnotism. Of these 100 were fully cured, in 98 there was a noticeable improvement, in 92 a slight one, and in only 71 were there no results; 58 cases were not followed. These cases included organic maladies of the nervous system, mental diseases, and neuralgia, besides others not directly connected with the nervous system. The treatment of the insane was especially discussed by others, and here, too, success has been obtained in some cases, though the difficulties are far greater than in physical maladies. A curious and interesting report was presented by one of the physicians in regard to his experiments with children, whom he found easier to influence by *suggestion* than their elders. In this he submitted as a proven conclusion the value of hypnotic suggestion as "an excellent auxiliary in the education of vicious or degenerate children," it being "especially efficient in reacting against vicious instincts, habitual lying, cruelty, theft, and inveterate idleness." This is, perhaps, one of the most startling assurances we are given of the powers of hypnotism in the hands of competent men; and such results, already attained, seem to point to possibilities of great importance in the further development of this study.

There is another side to all this, however, which the congress in Paris did not fail to consider. That is the danger of the abuse and the irresponsible use of the hypnotic phenomena.

Trick performances of travelling quacks are common, even in this country, and they are to be considered not only as a vulgarization of the science, but a danger to health and morals. Equal danger rests in opportunities that hypnotism affords the criminally inclined, which can easily be seen are numerous. A hypnotized subject is really made the instrument of vengeance or cupidity, quite unconsciously to himself, after emerging from the hypnotic state; and not only that, but may be made to take upon himself the sole blame. All these perils, it may be, will some time have to be guarded against, though knowledge of the subject is yet too restricted to make them alarming. But if this be so, it will be only one more instance, so many of which modern times can show, in which things of value to humanity are perverted to damaging uses. Of course, this unfortunate fact will not put an end to the investigations which promise so much of value; the advances made in this curious and, in its scientific application, so recent branch of scientific study will be watched with great interest.

Report of the Committee Appointed by the British Medical Association to Investigate the Nature of the Phenomena of Hypnotism—Its Value as a Therapeutic Agent, and the Propriety of Using It.

The Committee, having completed such investigation of hypnotism as time has permitted, have to report that they have satisfied themselves of the *genuineness of the hypnotic state.* No phenomena which have come under their observation, however, lend support to the theory of "animal magnetism."

Test experiments, which have been carried out by members of the Committee, have shown that this condition is attended by mental and physical phenomena, and that these differ widely in different cases.

Among the mental phenomena are altered consciousness, temporary limitation of will power, increased receptivity of suggestion from without, sometimes to the extent of producing passing delusions, illusions and hallucinations, an ex-

alted condition of the attention and post-hypnotic suggestions.

Among the physical phenomena are vascular changes (such as flushing of the face and altered pulse rate), deepening of the respirations, increased frequency of deglutition, slight muscular tremors, inability to control suggested movements, altered muscular sense, anæsthesia, modified power of muscular contraction, catalepsy and rigidity, often intense. It must, however, be understood that all these mental and physical phenomena are rarely present in any one case. The Committee takes this opportunity of pointing out that the term hypnotism is somewhat misleading, inasmuch as sleep, as ordinarily understood, is not necessarily present.

The Committee is of the opinion that, as a therapeutic agent, hypnotism is frequently *effective in relieving pain, procuring sleep* and alleviating many functional ailments. As to its permanent efficacy in the treatment of drunkenness, the evidence before the Committee is encouraging, but not conclusive.

Dangers in the use of hypnotism may arise from want of knowledge, carelessness or intentional abuse, or from the too continuous repetition of suggestions in unsuitable cases.

The Committee is of opinion that, when used for therapeutic purposes, its employment should be confined to qualified medical men, and that under no circumstances should female patients be hypnotized except in the presence of a relative or a person of their own sex.

In conclusion, the Committee desires to express its strong disapprobation of public exhibitions of hypnotic phenomena, and hopes that some legal restriction will be placed upon them.

F. NEEDHAM, *Chairman.*
T. OUTTERSON WOOD, *Hon. Sec.*

JULY, 1892.

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